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Preface

This book is written to support a one-semester general education course in physical science. The course is required of virtually all non-science students at our university (about 2500 per semester) although some satisfy the requirement by examination.

The course is meant to be a broad exposure to physical science. The students who take the course are primarily freshman who are not science majors, but who will follow the course with an elective which pursues some area of science in greater depth. The course is conceptual rather than mathematical. It is meant to be a presentation of some of the most significant ideas in science, as they might be presented to a lay audience by specialists. The course is supported by faculty lectures which include live demonstrations and audiovisual presentations without which the course would be much different and incomplete.

For a general education course to be a requirement for all, it must aspire to some level of universality. Preference must be given to that body of learning which prepares students for a lifetime of learning, learning extending beyond the university experience. It must focus on laws and principles with the most general applicability and on the conceptual frameworks and models with which the widest range of physical phenomena can be understood.

The course should help the student put in place theoretical structures into which he or she can integrate knowledge as it is accumulated after leaving the university. Such structures help to organize bodies of knowledge and establish proper relationships between their elements. Examples of such structures are Newton’s Laws of Motion, the Periodic Table of the Elements, and the Theory of Plate Tectonics. Each of these provides a framework for organizing large bodies of information while automatically establishing a relational structure between elements of information. Each of these would be recognized as a significant achievement of humanity.

Ideas should be given precedence which are representative of the thought of the greatest intellects of our race. Our minds are stretched most when we try to match them to the thoughts of our geniuses. Thus one must find in a physical science course which is to be a general requirement the names of Aristotle, Newton, Einstein, Bohr, and others, along with some of their ideas and how these have changed the way we view the world. Ideally, the course should try to capture some of the historical struggle to come to new understanding.

A theme of a generally-required course should be epistemology. Traditionally, we know, or we think we know, by authority, reasoning, intuition, and by the experience of our senses. Each of these has its strengths and weaknesses. Anyone who values learning must recognize what it means to “know” and should understand what empiricism can and cannot contribute to knowing. A far as possible, the student should be allowed to experience with his or her own senses some of the crucial observations. In the format we have chosen, we rely heavily on lecture demonstrations and audiovisual materials. We see the lack of an associated laboratory experience as a weakness in our own version of the course.

Throughout the course, the ideas should be illustrated with examples taken from common experience. Because time is limited and because these experiences are so broad and vary from instructor to instructor, they can serve as examples but cannot become an end in themselves. They are properly taken to illustrate the larger issues of the course.

We have chosen topics that address the following larger issues: What is the nature of motion? What is the nature of time and space? What is the nature of matter? How does life work? How do the heavens work? How does the earth work? Some specialized topics are included as prerequisites to these issues. In the prologue and at the end of several chapters, we have included short sections that give historical and philosophical perspectives on the development of ideas in science. Chapters 22 and 23 may go further into biology than one would expect in a physical science course but are intentionally included to make explicit the connection of physical and biological sciences. The historical perspectives and connections to biology are included to help fit the physical science course into the larger general education curriculum of the university.

We clearly recognize that our goals exceed our reach, but have nevertheless felt it worth the effort to try.

The text has been the work of several individuals in the College of Physical and Mathematical Sciences at Brigham Young University. We have benefited from many discussions with our colleagues and from their reviews. James Bills was particularly helpful in reviewing portions of the text, but we must also mention Irvin Bassett, William Dibble, Kent Harrison, and Kent Nielson. The text has roots in an earlier book authored by Jae Ballif and William Dibble. Kenneth Hamblin and Richard Snow made contributions to earlier editions of this text, which have also shaped the content. We also
acknowledge William Strong for managing the production of the book and those who have labored on the typing and revisions.
Preface to the Second Edition

With the second edition we continue the evolution of a textbook and course that have now been offered to about 100,000 students at our university over a period of more than 20 years. While the essential content and structure of the course have remained remarkably unchanged over that period, we include in this new edition changes and clarifications suggested to us by the experience of students, teaching assistants, and faculty. We have also included a Study Guide at the end of each chapter to give enhanced support to the objectives of the course.

The objectives of the course are:

1. To gain a conceptual understanding of most of the fundamental principles that govern the physical universe.

2. To understand how these few principles, and models that are consistent with them, explain much of what we observe directly in nature and some of what is observed when modern technology expands our view to include things that are very small and also things that are very large.

3. To understand how science works by assuming “self-evident truths,” postulating or guessing what might be, experimenting and using the measured results to test for consistency between what is guessed and what is observed. To understand the hope of scientists that as errors are discovered and rejected, it is possible to come closer to the “truth.” (See Appendix A for Suggestions for Study.)

In the Study Guide we identify and isolate the fundamental laws, principles, and models essential to the understanding of the chapter. The Study Guide section includes a glossary of important new terms. A list of exercise questions is provided, many of which have hints or answers provided at the back of the book.

Separate from the “Exercises” are the so-called “Focus Questions.” Students are encouraged to write out answers to this limited number of specific essay questions as a part of their study of each chapter with the promise that essay examination questions will be drawn from this specific set. Many of these questions are structured in the multipart form: What is observed? What is the principle or model involved? How do you explain what you see in terms of the principle or model? This format directly supports the objectives of our course.

The Focus Questions serve several purposes. First, they require students to put thoughts into writing. Second, for students who are apprehensive or even overwhelmed by their first exposure to physical science, the questions provide focus onto some of the most important concepts in a particular chapter. Finally, the questions, since they are common knowledge, provide a focus for discussion among students themselves and with our corps of teaching assistants so that they can help teach one another. This is particularly important in the large-enrollment format that we teach.

We are grateful to Jae Ballif and Laralee Ireland for their significant work in developing the concept and content of the Study Guide.

Many of our faculty who have taught the course have made specific suggestions for improvements. We gratefully acknowledge suggestions from Laralee Ireland, Byron Wilson, J. Ward Moody, Juliana Boerio-Goates, Nolan Mangelson, Kent Harrison, and Alvin Benson. We are fortunate to have the support of a large number of teaching assistants who staff a walk-in tutorial laboratory. Their direct experience with student questions and misconceptions has been very helpful in revising the book.

Since the preface to the first edition was written, we have incorporated a “laboratory experience” into the course. We are fortunate to have a variety of exploratorium-style exhibits in the foyer and hallways of our science building and a paleontology museum to which students are directed for out-of-class enrichment experiences that are correlated to course material. We are indebted to Freeman Andersen, Scott Daniel, and Wes Lifferth for creating and maintaining many of the hands-on public exhibits and displays that delight and teach our students and visitors to our campus alike.

We are especially grateful to Madlyn Tanner for editorial assistance, to Laralee Ireland for assistance with managing production of the text, and to Cheryl Van Ausdal for typing portions of the manuscript.

Finally, we thank those students who have, with delight and enthusiasm, come to see the world about them in a new way.