Preface

Creating Informed Citizens

The aim of *The Physical Universe* is to present, as simply and clearly as possible, the essentials of physics, chemistry, earth science, and astronomy to students whose main interests lie elsewhere.

Because of the scope of these sciences and because we assume minimal preparation on the part of the reader, our choice of topics and how far to develop them had to be limited. The emphasis throughout is on the basic concepts of each discipline. We also try to show how scientists approach problems and why science is a never-ending quest rather than a fixed set of facts.

The book concentrates on those aspects of the physical sciences most relevant to a nonscientist who wants to understand how the universe works and to know something about the connections between science and everyday life. We hope to equip readers to appreciate major developments in science as they arrive and to be able to act as informed citizens on matters that involve science and public policy. In particular, there are serious questions today concerning energy supply and use and the contribution of carbon dioxide emissions to global warming. Debates on these questions require a certain amount of scientific literacy, which this book is intended to provide, in order that sensible choices be made that will determine the welfare of generations to come. Past choices have not always benefited our planet and its inhabitants: it is up to us to see that future choices do.

> *"[Krauskopf/Beiser's* The Physical Universe*] is a good coverage of the basic physical sciences. It gives the basic principles of the different physical sciences and builds real content knowledge. (In contrast, so many texts now tend to "discuss" topics rather than developing an understanding of basic principles.) It has sufficient real-world applications to make the text interesting to the students. I like the way timely, controversial topics are discussed."*
>
> —Linda Arney Wilson, *Middle Tennessee State University*

Scope and Organization

There are many possible ways to organize a book of this kind. We chose the one that provides the most logical progression of ideas, so that each new subject builds on the ones that came before.

> *"This textbook has more of what we teach in Physical Science than any other book on the market. The improvement of each revision is great. . . . I have used 4 editions of this textbook because it is well written; the multiple choice questions and the*

end-of-the-chapter questions and problems provide numerous opportunities for the student to apply concepts discussed in each chapter. Numerous illustrations are provided for the more visual learner."

—Etta C. Gravely, *NC A&T University*

Our first concern in *The Physical Universe* is the scientific method, using as illustration the steps that led to today's picture of the universe and the earth's place in it. Next we consider motion and the influences that affect moving bodies. Gravity, energy, and momentum are examined, and the theory of relativity is introduced. Matter in its three states next draws our attention, and we pursue this theme from the kinetic-molecular model to the laws of thermodynamics and the significance of entropy. A grounding in electricity and magnetism follows, and then an exploration of wave phenomena that includes the electromagnetic theory of light. We go on from there to the atomic nucleus and elementary particles, followed by a discussion of the quantum theories of light and of matter that lead to the modern view of atomic structure.

"This was my favorite chapter [Chapter 1]. It was also my students' favorite. It generated a great deal of discussion and it motivated the students. . . . I was extremely impressed with how this text introduced the scientific method and then used that methodology to discuss one of the "Great Debates" in scientific history, Geocentric vs. Heliocentric. My students not only learned how the method is applied, but they enjoyed the banter of which view made sense. In fact, I received a number of emails where students went out on their own to do further investigation. . . . It also set the stage for more engaging conversation about the world around them."

—Leroy Salary, Jr., *Norfolk State University*

The transition from physics to chemistry is made via the periodic table. A look at chemical bonds and how they act to hold together molecules, solids, and liquids is followed by a survey of chemical reactions, organic chemistry, and the chemistry of life.

"My overall impression of Chapter 9 is that the author provides an excellent overview of the basic concepts associated with the periodic table. . . . The major strengths of this chapter are that the author provides adequate background information on each topic that allows any non-science major to comprehend and to connect each concept with the previous concept. . . . The authors do a great job of explaining the historical relevance of the periodic table and they give an excellent introduction of the definition of what is CHEMISTRY by painting a clear picture of how to relate atoms and elements to compounds and chemical reactions."

—Antonie H. Rice, *University of Arkansas at Pine Bluff*

Our concern next shifts to the planet on which we live, and we begin by inquiring into the oceans of air and water that cover it. From

there we proceed to the materials of the earth, to its ever-evolving crust, and to its no-longer-mysterious interior. After a brief narrative of the earth's geological history we go on to what we know about our nearest neighbors in space—planets and satellites, asteroids, meteoroids, and comets.

Now the sun, the monarch of the solar system and the provider of nearly all our energy, claims our notice. We go on to broaden our astronomical sights to include the other stars, both individually and as members of the immense assemblies called galaxies. The evolution of the universe starting from the big bang is the last major subject, and we end with the origin of the earth and the likelihood that other inhabited planets exist in the universe and how we might communicate with them.

> *"With the various spacecraft in the last couple of decades, the Hubble Space Telescope, and the ongoing study of lunar samples and meteorites, there is an immense amount of information that is available for inclusion in a chapter [Chapter 16] such as this. The authors have done an excellent job of deciding what to include, and the result is an excellent overview chapter that is as current as it can be in this rapidly growing subject."*
>
> —Eric Jerde, *Morehead State University*

> *"This is one of the best chapters [Chapter 17] on stars in a text of this level that I have read. It addresses the various aspects of the stars (size, distance, evolution, etc.) in an easy to understand manner. It also provides information concerning the history of the current knowledge of stars."*
>
> —Wilda Pounds, *Northeast Mississippi Community College*

Mathematical Level

The physical sciences are quantitative, which has both advantages and disadvantages. On the plus side, the use of mathematics allows many concepts to be put in the form of clear, definite statements that can be carried further by reasoning and whose predictions can be tested objectively. Less welcome is the discomfort many of us feel when faced with mathematical discussions.

The mathematical level of *The Physical Universe* follows Albert Einstein's prescription for physical theories: "Everything should be as simple as possible, but not simpler." A modest amount of mathematics enables the book to show how science makes sense of the natural world and how its findings led to the technological world of today. To give two examples, the formula $\frac{1}{2}mv^2$ does not have to be pulled out of a hat here, and how the mole connects chemical ideas with actual measurements can be explored. In general, the more complicated material supplements rather than dominates the presentation, and full mastery is not needed to understand the rest of the book. The basic algebra needed is reviewed in the Math Refresher. Powers-of-ten notation for small and large numbers is carefully explained there. This section is self-contained and can provide all the math background needed.

"The author has done a wonderful job balancing the verbal and mathematical explanations. The clear, well-labeled diagrams included to assist understanding mathematical expressions are excellent."

—Paul A. Withey, *Northwestern State University of Louisiana*

New To This Edition

Because the organization of the previous edition worked well in the classroom, it was not altered. The principal changes for this edition were these:

Text Revision Recent findings in the physical sciences were incorporated where appropriate, notably in astronomy but elsewhere as well. Several new topics were introduced, such as polarized light, and a number of sections were rewritten for greater clarity. The increasingly serious issues centered on energy supply and use were given expanded treatments to enable the reader to see what is involved and what can be done to prevent future disaster. Matters involving fossil fuels, pollution, nuclear energy, renewable sources (including biofuels), energy conservation (both in industry and the home and with regard to cars), carbon dioxide emissions and their connection to global warming—all are examined in detail.

Chapter Goals Each chapter now starts with a series of goals that working through the chapter should bring within reach. The list is meant to help the reader focus on what is most significant in the chapter contents.

Illustrations The illustrations, both line drawings and photographs, are full partners to the text and provide a visual pathway to understanding scientific observations and principles for students unaccustomed to abstract argument. Twenty-seven new illustrations are included in this edition.

Exercises The questions and problems are now arranged at the end of each chapter according to the corresponding text section. Each group begins with questions and goes on to problems. In all there are nearly 300 new exercises, divided between replacements and additions, for an increased total of 1830.

Worked Examples There are now worked examples in all chapters. For this edition, the examples total 101 of which 42 are new. Many of the new ones are conceptual, showing how basic ideas can be used to analyze and answer complex questions.

Math Level How much mathematics is appropriate for a given classroom is for each individual instructor to decide. To this end, a section has been added to the twelfth edition Instructor's Manual that lists the slightly more difficult computational material from the text. This material can be covered as needed or omitted without affecting the continuity or conceptual coverage of a course.


2 Motion

GOALS

When you have completed this chapter you should be able to:

- Distinguish between instantaneous and average speeds.
- Use the formula $v = d/t$ to solve problems that involve distance, time, and speed.
- Distinguish between scalar and vector quantities and give several examples of each.
- Use the Pythagorean theorem to add two vector quantities of the same kind that act at right angles to each other.
- Define acceleration and find the acceleration of an object whose speed is changing.
- Use the formula $v_2 = v_1 + at$ to solve problems that involve speed, acceleration, and time.
- Use the formula $d = v_1t + \frac{1}{2}at^2$ to solve problems that involve distance, time, speed, and acceleration.
- Explain what is meant by the acceleration of gravity.
- Describe the effect of air resistance on falling objects.
- Separate the velocity of an object into vertical and horizontal components in order to determine its motion.
- Define force and indicate its relationship to the first law of motion.
- Discuss the significance of the second law of motion, $F = ma$.
- Distinguish between mass and weight and find the weight of an object of given mass.
- Use the third law of motion to relate action and reaction forces.
- Explain the significance of centripetal force in motion along a curved path.
- Relate the centripetal force on an object moving in a circle to its mass, speed, and the radius of the circle.
- State Newton's law of gravity and describe how gravitational forces vary with distance.
- Account for the ability of a satellite to orbit the earth without either falling to the ground or flying off into s
- Define escape speed.

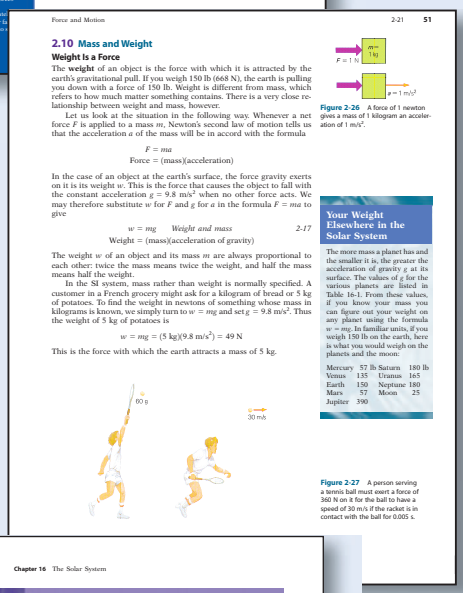
Astronaut Bruce McCandless near the orbiting Space Shuttle Challenger.

Describing Motion
2.1 Speed — *How Fast Is Fast*
2.2 Vectors — *Which Way as Well as How Much*
2.3 Acceleration — *Vroom!*
2.4 Distance, Time, and Acceleration — *How Far?*

Acceleration of Gravity
2.5 Free Fall — *What Goes Up Must Come Down*
2.6 Air Resistance — *Why Raindrops Don't Kill*

Force and Motion
2.7 First Law of Motion — *Constant Velocity Is as Natural as Being at Rest*
2.8 Mass — *A Measure of Inertia*
2.9 Second Law of Motion — *Force and Acceleration*
2.10 Mass and Weight — *Weight Is a Force*
2.11 Third Law of Motion — *Action and Reaction*

Gravitation
2.12 Circular Motion — *A Curved Path Requires an Inward Pull*
2.13 Newton's Law of Gravity — *What Holds the Solar System Together*
2.14 Artificial Satellites — *Thousands Circle the Earth*


Force and Motion 2-21 51

2.10 Mass and Weight

Weight Is a Force

The **weight** of an object is the force with which it is attracted by the earth's gravitational pull. If you weigh 150 lb (668 N), the earth is pulling you down with a force of 150 lb. Weight is different from mass, which refers to how much matter something contains. There is a very close relationship between weight and mass, however.

Let us look at the situation in the following way. Whenever a net force F is applied to a mass m, Newton's second law of motion tells us that the acceleration a of the mass will be in accord with the formula

$$F = ma$$
$$\text{Force} = (\text{mass})(\text{acceleration})$$

In the case of an object at the earth's surface, the force gravity exerts on it is its weight w. This is the force that causes the object to fall with the constant acceleration $g = 9.8\ \text{m/s}^2$ when no other force acts. We may therefore substitute w for F and g for a in the formula $F = ma$ to give

$$w = mg \quad \textit{Weight and mass} \quad 2\text{-}17$$
$$\text{Weight} = (\text{mass})(\text{acceleration of gravity})$$

The weight w of an object and its mass m are always proportional to each other: twice the mass means twice the weight, and half the mass means half the weight.

In the SI system, mass rather than weight is normally specified. A customer in a French grocery might ask for a kilogram of bread or 5 kg of potatoes. To find the weight in newtons of something whose mass in kilograms is known, we simply turn to $w = mg$ and set $g = 9.8\ \text{m/s}^2$. Thus the weight of 5 kg of potatoes is

$$w = mg = (5\ \text{kg})(9.8\ \text{m/s}^2) = 49\ \text{N}$$

This is the force with which the earth attracts a mass of 5 kg.

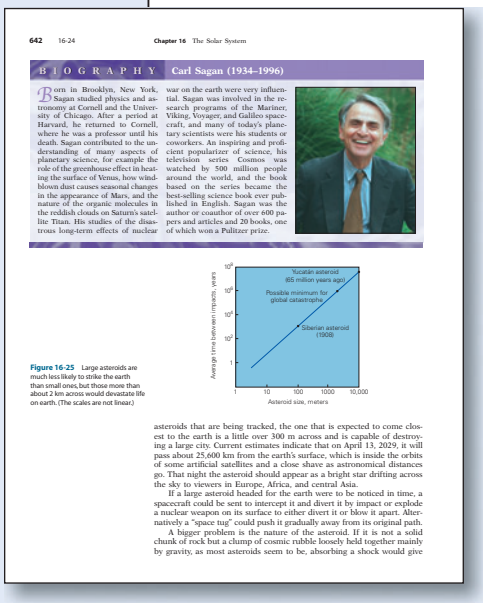
Figure 2-26 A force of 1 newton gives a mass of 1 kilogram an acceleration of 1 m/s².

Your Weight Elsewhere in the Solar System

The more mass a planet has and the smaller it is, the greater the acceleration of gravity g at its surface. The values of g for the various planets are listed in Table 16-1. From these values, if you know your mass you can figure out your weight on any planet using the formula $w = mg$. In familiar units, if you weigh 150 lb on the earth, here is what you would weigh on the planets and the moon:

Mercury	57 lb	Saturn	180 lb
Venus	135	Uranus	165
Earth	150	Neptune	180
Mars	57	Moon	25
Jupiter	390		

Figure 2-27 A person serving a tennis ball must exert a force of 360 N on it for the ball to have a speed of 30 m/s if the racket is in contact with the ball for 0.005 s.


642 16-24 Chapter 16 The Solar System

BIOGRAPHY Carl Sagan (1934–1996)

Born in Brooklyn, New York, Sagan studied physics and astronomy at Cornell and the University of Chicago. After a period at Harvard, he returned to Cornell, where he was a professor until his death. Sagan contributed to the understanding of many aspects of planetary science, for example the role of the greenhouse effect in heating the surface of Venus, how windblown dust causes seasonal changes in the appearance of Mars, and the nature of the organic molecules in the reddish clouds on Saturn's satellite Titan. His studies of the disastrous long-term effects of nuclear war on the earth were very influential. Sagan was involved in the research programs of the Mariner, Viking, Voyager, and Galileo spacecraft, and many of today's planetary scientists were his students or coworkers. An inspiriting and proficient popularizer of science, his television series Cosmos was watched by 500 million people around the world, and the book based on the series became the best-selling science book ever published in English. Sagan was the author or coauthor of over 600 papers and articles and 20 books, one of which won a Pulitzer prize.

Figure 16-25 Large asteroids are much less likely to strike the earth than small ones, but those more than about 2 km across would devastate life on earth. (The scales are not linear.)

asteroids that are being tracked, the one that is expected to come closest to the earth is a little over 300 m across and is capable of destroying a large city. Current estimates indicate that on April 13, 2029, it will pass about 25,600 km from the earth's surface, which is inside the orbits of some artificial satellites and a close shave as astronomical distances go. That night the asteroid should appear as a bright star drifting across the sky to viewers in Europe, Africa, and central Asia.

If a large asteroid headed for the earth were to be noticed in time, a spacecraft could be sent to intercept it and divert it by impact or explode a nuclear weapon on its surface to either divert it or blow it apart. Alternatively a "space tug" could push it gradually away from its original path.

A bigger problem is the nature of the asteroid. If it is not a solid chunk of rock but a clump of cosmic rubble loosely held together mainly by gravity, as most asteroids seem to be, absorbing a shock would give

The Learning System

A variety of aids are provided in *The Physical Universe* to help the reader master the text.

Chapter Opener An outline provides a preview of major topics, showing at a glance what the chapter covers. A list of goals helps to focus the reader on what is most important in the chapter.

Worked Examples A full grasp of physical and chemical ideas includes an ability to solve problems based on these ideas. Some students, although able to follow the discussions in the book, nevertheless may have trouble putting their knowledge to use in this way. To help them, detailed solutions of typical problems are provided that show how to apply formulas and equations to real-world situations. Besides the worked examples, outline solutions for half the end-of-chapter exercises are given at the end of the text, which include over 200 model problem solutions. Thinking through these solutions should bring the unsolved even-numbered problems within reach. In addition to its role in reinforcing the understanding of physical and chemical ideas, solving problems can provide great pleasure, and it would be a shame to miss out on this pleasure. The worked examples are not limited to problems—nearly half of them show how basic ideas can be used to answer serious questions that do not involve calculations.

"Great idea! Having the examples clearly off-set from the rest of the text makes them easy to find. . . . I am particularly pleased to be able to point out the examples in each chapter. I believe that this feature will be a great benefit to me and my students."

—T. D. Saunc, *Angelo State University*

Bringing Science to Life

Biographies Brief biographies of 40 major figures in the development of the physical sciences appear where appropriate throughout the text. The biographies provide human and historical perspectives by attaching faces and stories to milestones in these sciences.

Sidebars These are brief accounts of topics related to the main text. A sidebar may provide additional information on a particular subject, comment on its significance, describe its applications, consider its historical background, or present recent findings. Fifteen new ones have been added for this edition.

"The textbook does a nice job of covering contemporary topics, which is a way to keep non-science majors interested. I also like the biographies and have sometimes assigned students to

go deeper into someone's biography and report to class. Somehow, making these scientists become 'real' for the students makes them enjoy the course more. I also like to show them how some of the topics covered in the course are fairly recent, how there are things we still do not understand. It is important for them to know that science is alive and continues to develop its body of knowledge."

—Ana Ciereszko, *Miami Dade College*

At Work Essays Four scientists in midcareer who have carried out important research in their respective fields have contributed accounts of how their days at work are spent. The enthusiasm and dedication they bring to their probes of the physical universe show clearly in these essays.

End of Chapter Features

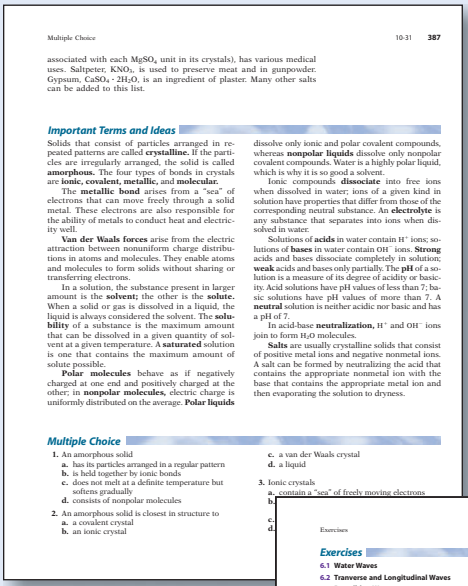
Important Terms and Ideas Important terms introduced in the chapter are listed together with their meanings, which serves as a chapter summary. A list of the **Important Formulas** needed to solve problems based on the chapter material is also given where appropriate.

Exercises An average of over a hundred exercises on all levels of difficulty follow each chapter. They are of three kinds, multiple choice, questions, and problems:

- **Multiple Choice** An average chapter has 41 Multiple-Choice exercises (with answers) that act as a quick, painless check on understanding. Correct answers provide reinforcement and encouragement; incorrect ones identify areas of weakness.
- **Exercises** Exercises consist of both questions and problems. Some of the questions are meant to find out how well the reader has understood the chapter material. Others ask the reader to apply what he or she has learned to new situations. Answers to the odd-numbered questions are given at the back of the book. The physics and chemistry chapters include problems that range from quite easy to moderately challenging. The ability to work out such problems signifies a real understanding of these subjects. Outline solutions (not just answers) for the odd-numbered problems are given at the back of the book.

"The multiple-choice exercises and the questions and problems are a very nice feature of this book and it is definitely above average. . . . There is a good balance between the conceptual versus computational questions."

—Omar Franco Guerrero, *University of Delaware*



Multiple Choice 10-31 387

associated with each $MgSO_4$ unit in its crystals), has various medical uses. Saltpeter, KNO_3, is used to preserve meat and in gunpowder. Gypsum, $CaSO_4 \cdot 2H_2O$, is an ingredient of plaster. Many other salts can be added to this list.

Important Terms and Ideas

Solids that consist of particles arranged in repeated patterns are called **crystalline.** If the particles are irregularly arranged, the solid is called **amorphous.** The four types of bonds in crystals are **ionic, covalent, metallic,** and **molecular.**

The **metallic bond** arises from a "sea" of electrons that can move freely through a solid metal. These electrons are also responsible for the ability of metals to conduct heat and electricity well.

Van der Waals forces arise from the electric attraction between nonuniform charge distributions in atoms and molecules. They enable atoms and molecules to form solids without sharing or transferring electrons.

In a solution, the substance present in larger amount is the **solvent;** the other is the **solute.** When a solid or gas is dissolved in a liquid, the liquid is always considered the solvent. The **solubility** of a substance is the maximum amount that can be dissolved in a given quantity of solvent at a given temperature. A **saturated** solution is one that contains the maximum amount of solute possible.

Polar molecules behave as if negatively charged at one end and positively charged at the other; in **nonpolar molecules,** electric charge is uniformly distributed on the average. **Polar liquids** dissolve only ionic and polar covalent compounds, whereas **nonpolar liquids** dissolve only nonpolar covalent compounds. Water is a highly polar liquid, which is why it is so good a solvent.

Ionic compounds **dissociate** into free ions when dissolved in water; ions of a given kind in solution have properties that differ from those of the corresponding neutral substance. An **electrolyte** is any substance that separates into ions when dissolved in water.

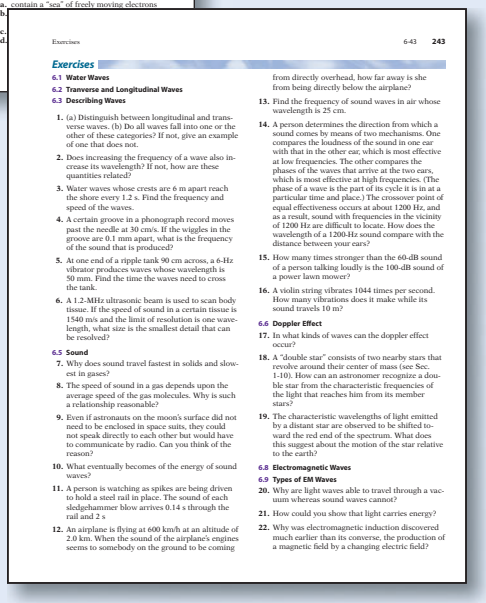
Solutions of **acids** in water contain H^+ ions; solutions of **bases** in water contain OH^- ions. **Strong** acids and bases dissociate completely in solution; **weak** acids and bases only partially. The **pH** of a solution is a measure of its degree of acidity or basicity. Acid solutions have pH values of less than 7; basic solutions have pH values of more than 7. A **neutral** solution is neither acidic nor basic and has a pH of 7.

In acid-base **neutralization,** H^+ and OH^- ions join to form H_2O molecules.

Salts are usually crystalline solids that consist of positive metal ions and negative nonmetal ions. A salt can be formed by neutralizing the acid that contains the appropriate nonmetal ion with the base that contains the appropriate metal ion and then evaporating the solution to dryness.

Multiple Choice

1. An amorphous solid
   a. has its particles arranged in a regular pattern
   b. is held together by ionic bonds
   c. does not melt at a definite temperature but softens gradually
   d. consists of nonpolar molecules
2. An amorphous solid is closest in structure to
   a. a covalent crystal
   b. an ionic crystal
   c. a van der Waals crystal
   d. a liquid
3. Ionic crystals
   a. contain a "sea" of freely moving electrons



Exercises 6-43 243

Exercises

6.1 Water Waves
6.2 Tranverse and Longitudinal Waves
6.3 Describing Waves

1. (a) Distinguish between longitudinal and transverse waves. (b) Do all waves fall into one or the other of these categories? If not, give an example of one that does not.
2. Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related?
3. Water waves whose crests are 6 m apart reach the shore every 1.2 s. Find the frequency and speed of the waves.
4. A certain groove in a phonograph record moves past the needle at 30 cm/s. If the wiggles in the groove are 0.1 mm apart, what is the frequency of the sound that is produced?
5. At one end of a ripple tank 90 cm across, a 6-Hz vibrator produces waves whose wavelength is 50 mm. Find the time the waves need to cross the tank.
6. A 1.2-MHz ultrasonic beam is used to scan body tissue. If the speed of sound in a certain tissue is 1540 m/s and the limit of resolution is one wavelength, what size is the smallest detail that can be resolved?

6.5 Sound

7. Why does sound travel fastest in solids and slowest in gases?
8. The speed of sound in a gas depends upon the average speed of the gas molecules. Why is such a relationship reasonable?
9. Even if astronauts on the moon's surface did not need to be enclosed in space suits, they could not speak directly to each other but would have to communicate by radio. Can you think of the reason?
10. What eventually becomes of the energy of sound waves?
11. A person is watching as spikes are being driven to hold a steel rail in place. The sound of each sledgehammer blow arrives 0.14 s through the rail and 2 s
12. An airplane is flying at 600 km/h at an altitude of 2.0 km. When the sound of the airplane's engines seems to somebody on the ground to be coming from directly overhead, how far away is she from being directly below the airplane?
13. Find the frequency of sound waves in air whose wavelength is 25 cm.
14. A person determines the direction from which a sound comes by means of two mechanisms. One compares the loudness of the sound in one ear with that in the other ear, which is most effective at low frequencies. The other compares the phases of the waves that arrive at the two ears, which is most effective at high frequencies. (The phase of a wave is the part of its cycle it is in at a particular time and place.) The crossover point of equal effectiveness occurs at about 1200 Hz, and as a result, sound with frequencies in the vicinity of 1200 Hz are difficult to locate. How does the wavelength of a 1200-Hz sound compare with the distance between your ears?
15. How many times stronger than the 60-dB sound of a person talking loudly is the 100-dB sound of a power lawn mower?
16. A violin string vibrates 1044 times per second. How many vibrations does it make while its sound travels 10 m?

6.6 Doppler Effect

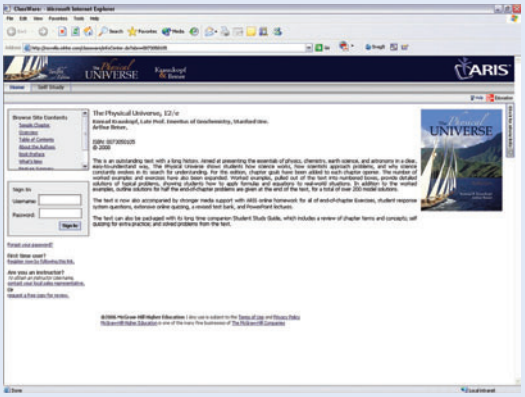
17. In what kinds of waves can the doppler effect occur?
18. A "double star" consists of two nearby stars that revolve around their center of mass (see Sec. 1-10). How can an astronomer recognize a double star from the characteristic frequencies of the light that reaches him from its member stars?
19. The characteristic wavelengths of light emitted by a distant star are observed to be shifted toward the red end of the spectrum. What does this suggest about the motion of the star relative to the earth?

6.8 Electromagnetic Waves
6.9 Types of EM Waves

20. Why are light waves able to travel through a vacuum whereas sound waves cannot?
21. How could you show that light carries energy?
22. Why was electromagnetic induction discovered much earlier than its converse, the production of a magnetic field by a changing electric field?

Additional Resources for *The Physical Universe*

McGraw-Hill's ARIS—Assessment, Review, and Instruction System



McGraw-Hill's ARIS for *The Physical Universe* is a complete, online electronic homework and course management system, designed for greater ease of use than any other system available. Created specifically for *The Physical Universe*, twelfth edition text, instructors can create and share course materials and assignments with colleagues with a few clicks of the mouse. For instructors, an instructor's manual, personal response system questions, all PowerPoint lectures, and assignable content are directly tied to text-specific materials in *The Physical Universe*. Instructors can also edit questions, import their own content, and create announcements and due dates for assignments. ARIS has automatic grading and reporting of easy-to-assign homework, quizzing, and testing. All student activity within McGraw-Hill's ARIS is automatically recorded and available to the instructor through a fully integrated grade book that can be downloaded to Excel. For students, there are daily concept quizzes, study guide quizzes, multiple-choice quizzes, matching exercises, animations, and even more materials that may be used for self-study or in combination with assigned materials.

ARIS Presentation Center

The ARIS Presentation Center is the ultimate multimedia resource center for the instructor. Located within McGraw-Hill's ARIS—Assessment, Review, and Instruction System, this online site allows instructors to utilize graphics from the textbook and also provides the option to search by topic within all other McGraw-Hill ARIS Presentation Center sites. Graphics are available in electronic format to create customized classroom presentations, visually based tests and quizzes, dynamic course website content, or attractive printed support materials.

The following assets are available in digital formats, grouped by chapter:

- **Art and Photos** Full-color digital files of all of the illustrations and many of the photos in the text can be readily incorporated into lecture presentations, exams, or custom-made classroom materials.
- **Worked Examples and Tables** All worked examples and tables from the text are provided in electronic format for inclusion in classroom resources.
- **Animations** Numerous full-color animations that support the topics discussed in the text are provided. Instructors are able to harness the visual impact of processes in motion by importing these files into classroom presentations or online course materials.

- **PowerPoint Lecture Outlines** Ready-made presentations that combine art, animation, and lecture notes are provided for each of the 18 chapters of the text. These outlines can be used as they are or tailored to reflect preferred lecture topics and sequences.
- **PowerPoint Slides** For instructors who prefer to create their own, individualized lectures, all illustrations, photos, tables, and worked examples are pre-inserted by chapter into blank PowerPoint slides for convenience.

CPS eInstruction

The Classroom Performance System (CPS) brings interactivity into the classroom or lecture hall. It is a wireless response system that gives the instructor and students immediate feedback from the entire class. The wireless response pads are essentially remotes that are easy to use and engage students. CPS allows instructors to motivate student preparation, interactivity, and active learning. Instructors receive immediate feedback to assess which concepts students understand. Questions covering the content of *The Physical Universe* text and formatted in the CPS eInstruction software and PowerPoint are available on ARIS for *The Physical Universe* and the Instructor's Testing and Resource CD-ROM.

> *"I require students to use eInstruction's remotes. I use the remotes to measure whether students have mastered some of the important concepts. . . . I find them very useful—they give me immediate feedback—they allow daily attendance to be taken quickly and rather painlessly."*
>
> —Robert J. Backes, *Pittsburg State University*

Instructor's Testing and Resource CD-ROM

The cross-platform CD-ROM contains the Instructor's Manual and Test Bank, available in both Word and PDF formats. The Instructor's Manual, written by the text's authors, provides answers to the even-numbered end-of-chapter exercises not provided in the text. The Instructor's Manual also provides guidance on incorporating mathematics into the course. The Test Bank of over 900 additional questions and problems can be used for homework assignments and/or the preparation of exams. These Test Bank questions are also included on the CD-ROM within a computerized test bank. The user-friendly EZTest software can be used to quickly create customized exams by allowing instructors to sort questions by format; edit existing questions or add new ones; and scramble questions for multiple versions of the same test. Files for other questions from the ARIS quizzes, the

Student Study Guide, and CPS eInstruction are also provided on the CD-ROM.

> *"I use the ARIS Presentation Center to prepare all my lectures in PowerPoint, since I develop my lectures to my liking. All tests are prepared using the test bank provided by the publisher. . . . These materials have tremendously lightened my workload. I haven't had to re-invent the wheel so to speak. I can change my exams every semester and shuffle my answers from class to class. Well done."*
>
> —Colley Baldwin, *Medgar Evers College, CUNY*

Student Study Guide

Another helpful resource can be found in *The Physical Universe* Student Study Guide. With this Study Guide, students will maximize their use of *The Physical Universe* text package. It supplements the text with additional, self-directed activities and complements the text by focusing on the important concepts, theories, facts, and processes presented by the authors.

Overhead Transparencies

A set of over 100 full-color transparencies features images from the text. The images have been modified to ensure maximum readability in both small and large classroom settings.

Primis Online

This text can be customized in print or in an electronic format to meet exact course needs. McGraw-Hill's Primis Online allows instructors to select desired chapters and preferred sequence and to choose supplements from the many science items on our database. Visit **http://www.primiscontentcenter.com/** to begin today.

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Arthur Beiser

Meet the Authors

Konrad B. Krauskopf was born and raised in Madison, Wisconsin and earned a B.S. in chemistry from University of Wisconsin in 1931. He then earned a Ph.D. in chemistry at the University of California in Berkeley. When the Great Depression made jobs in chemistry scarce, Professor Krauskopf decided to study geology, which had long fascinated him. Through additional graduate work at Stanford University, he earned a second Ph.D. and eventually a position on the Stanford faculty. He remained at Stanford until his retirement in 1976. During his tenure, Professor Krauskopf also worked at various times with the U.S. Geological Survey, served with the U.S. army in occupied Japan, and traveled to Norway, France, and Germany on sabbatical leaves. His research interests included field work on granites and metamorphic rocks and laboratory study on applications of chemistry to geologic problems, especially the formation of ore deposits. In later years, Professor Krauskopf spent time working with various government agencies on the problem of radioactive waste disposal. Professor Krauskopf passed away on May 8, 2003.

Arthur Beiser, a native of New York City, received B.S., M.S., and Ph.D. degrees in physics from New York University, where he later served as Associate Professor of Physics. He then was Senior Research Scientist at the Lamont Geological Observatory of Columbia University. His research interests were chiefly in cosmic rays and in magnetohydrodynamics as applied to geophysics and astrophysics. In addition to theoretical work, he participated in a cosmic-ray expedition to an Alaskan peak and directed a search for magnetohydrodynamic waves from space in various Pacific locations. A Fellow of The Explorers Club, Dr. Beiser was the first chairman of its Committee on Space Exploration. He is the author or coauthor of 36 books, mostly college texts on physics and mathematics, 14 of which have been translated into a total of 22 languages. Two of his books are on sailing, The *Proper Yacht* and *The Sailor's World*. Figure 12-18 is a photograph of Dr. Beiser at the helm of his 58-ft sloop; he and his wife Germaine have sailed over 130,000 miles, including two Atlantic crossings and a rounding of Cape Horn. Germaine Beiser, who has degrees in physics from the Massachusetts Institute of Technology and New York University, is the author or coauthor of 7 books on various aspects of physics and has contributed to *The Physical Universe*.