C. Chapter Discussions

PART TWO OF TEXTBOOK

CHAPTER 10. ELECTRICITY AND MAGNETISM

Suggested Mini-Laboratory Explorations

- Our Place in Space.
- Portions of the major laboratories below might also be used as mini-laboratories.

Suggested Major Laboratory Explorations

- Exploring Electric Charges, Magnetic Poles, and Gravitation.
- Investigating Electric Currents I or II.
- Investigating Measurements and Uncertainty.

Demonstrations

Many of the concepts here can and should be demonstrated in class, with student participation. It would be especially helpful to demonstrate in class some of the phenomena the students will later encounter themselves in the laboratory.

If equipment is available, Oersted's experiment (Section 10.9) and the creation of an electromagnet (Section 10.8) should be demonstrated.

Objectives

This chapter introduces students to another set of fundamental concepts and theories in physics—electricity and magnetism. Students learn about the origins of the concepts of magnetic poles and electric charges, the differences and similarities between electric, magnetic, and gravitational forces, the concepts of fields and currents, the unification of electricity and magnetism, and application to accounting for friction and the hardness of objects.

Suggestions

This chapter covers a great deal of fundamental physics as well as providing important examples of the processes of theory construction, operational definitions, and the connection of these developments with emerging technologies. Forthcoming chapters will rely upon and extend many of these concepts. Fields and electrodynamics are discussed further in Chapter 12. Electric forces were important in formulating early atomic models (Chapters 13 and 14). Currents and their origins are revisited in Chapter 16. And technological applications, such as the generator, motor, and light bulb, are discussed in Chapter 11.

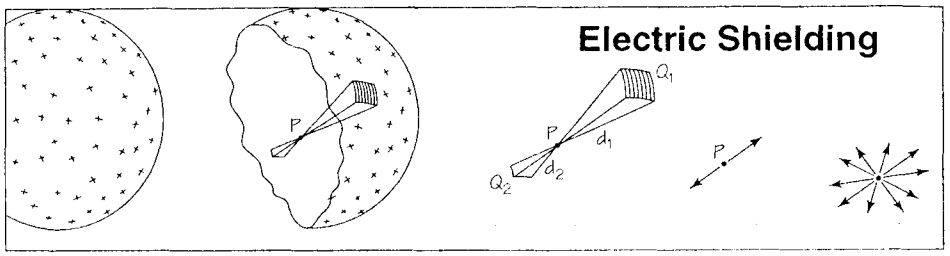
Many of the concepts in this chapter are fundamental to all of physics, yet sometimes difficult for students to grasp. Leave as much time as possible for students to assimilate the material. They may have encountered some of these concepts in the past but their understanding of them is often only partial. Students should also have as much opportunity as possible to encounter the phenomena and concepts in the laboratory in parallel with their reading of the text.

Further Information

Electric Shielding

In general, charges on a closed conducting surface arrange themselves so that the electric force inside is zero just as they do on a sphere as shown in the diagrams. Even if the conductor is placed in an electric field, the surface charges will rearrange themselves so as to keep the net force zero everywhere inside. Thus, the region inside any closed conductor is "shielded" from any *external* electric field. This is a very important practical principle.

Whenever stray electric fields might disturb the operation of some electric equipment, the equipment can be enclosed in a shell of conducting material.



Consider any point charge P inside an even, spherical distribution of charges. For any small patch of charges with total charge Q_1 on the sphere, there is a corresponding patch on the other side of P with total charge Q_2. But the areas of the patches are directly proportional to the squares of the distances from P. Therefore, the total charges Q_1 and Q_2 are also directly proportional to the squares of the distances from P. The electric field due to each patch of charge is proportional to the area of the patch, and inversely proportional to the square of the distance from P. So the distance and area factors cancel. The forces on P due to the two patches at P are exactly equal in magnitude. But the forces are also in opposite directions. So the net force on P is zero owing to Q_1 and Q_2. Since this is true for all pairs of charge patches, the net electric field at P is zero.

Further Reading

A.B. Arons, *A Guide to Introductory Physics Teaching* (New York: Wiley, 1990). Chapters 6–8 contain much valuable wisdom. The major laboratory on electrostatics draws upon and was inspired by Chapter 6.

B. Franklin, *The Autobiography of Benjamin Franklin* (New Haven: Yale University Press, 1964)

G. Holton and S.G. Brush, *Physics, The Human Adventure* (Piscataway, NJ: Rutgers University Press, 2001), Chapter 24.

L.C. McDermott et al., *Physics by Inquiry* (New York: Wiley, 1996). Volume 1 offers further inquiry investigations on the properties of magnets. Volume 2 offers an extensive series of inquiries on electric circuits.

P.S. Shaffer and L.C. McDermott, Research as a guide for curriculum development: An example from introductory electricity. Part I: Investigation of student understanding, *Am. J. Phys.*, **60** (1992), 994–1003; Part II: Design of instructional strategies, *Am. J. Phys.*, **60** (1992), 1004–1012.

C.E. Swartz and T. Miner, *Teaching Introductory Physics: A Sourcebook* (Woodbury, NY: AIP Press, 1997), Chapters 16–18.

Web sites

Physicsweb.org/tiptop/lab; Exploresource.com; http://web.mit.edu/jbelcher/www/anim.html

CHAPTER 11. THE ELECTRIC AGE

Demonstrations

Such demonstration equipment as induction coils, an instructional electric motor, and a hand-cranked generator will aid in demonstrating some of the basic principles and devices in this chapter.

Objectives

This chapter emphasizes one of the themes of this text: advances in scientific knowledge often have profound practical applications. The production of usable electrical energy is essential to the growth and continuation of modern industrial economies. The first half of the chapter draws upon knowledge gained in Chapter 10, in discussing the inventions of the motor, generator, and light bulb. The second half of the chapter presents the problem of the continuing need to generate large amounts of electrical energy and the advantages and disadvantages of all currently available options for doing so.

Suggestions

Since this chapter touches upon economic and technological choices that can be made only by public decisions, there is plenty of opportunity for students to develop informed opinions after these and related issues. They should be encouraged to do so, either informally or through outside projects as time and resources permit. This is in keeping with one of the goals of a course such as this: to prepare citizens to make informed decisions about technologically based social and economic issues.

Further Reading

A. Hobson, *Physics: Concepts and Connections*, 2nd ed. (Upper Saddle River, NJ: Prentice-Hall, 1999), Chapter 16 and 17.

C.E. Swartz and T. Miner, *Teaching Introductory Physics: A Sourcebook* (Woodbury, NY: AIP Press, 1997), Chapter 19.

Technology Insert: Two American Technologies

Bibliography

Telephone Technology

R.V. Bruce, Alexander Graham Bell and the conquest of solitude, In: C.W. Pursell, Jr., ed., *Technology in America* (Cambridge, MA: MIT Press, 1989), pp. 105–116.

Other Sources:

J. Brooks, *Telephone: The First Hundred Years* (New York: Harper and Row, 1976).
R.V. Brice, *Bell: Alexander Graham Bell and the Conquest of Solitude* (Boston: Little Brown, 1973).
B.S. Finn, Alexander Graham Bell's experiments with the variable resistance transmitter, *Smithsonian J. History*, **1**, (1966), pp. 1–16.
C. Fischer, *American Calling: A Social History of the Telephone* (Berkeley, CA: University of California Press, 1992).
L. Galambos, *The AT&T Series: 6 Volumes of Telephone History* (Baltimore, MD: John Hopkins Press, 1995).
G.E. Gorman, M. Mehalik, W.B. Carson, and M. Oblon, Alexander Graham Bell, Elisha Gray and the speaking telegraph: A cognitive comparison, *History of Technology* (1993).
D.A. Hounshell, Two paths to the telephone, *Scientific American*, **244** (1981), 156–163.
H.I. Schiller, *Mass Communications and American Empire* (New York: Kelley, 1969).
E. Stern and E. Gwathemy, *Once Upon a Telephone: An Illustrated Social History* (New York: Harcourt Brace, 1994).
R.L. Thompson, *Writing a Continent: The History of the Telegraph Industry in the United States, 1832–1866* (Princeton, NJ: Princeton University Press, 1947).

Automobile Technology

J.J. Fink, Henry Ford and the triumph of the automobile, In: C.W. Pursell, Jr., ed., *Technology in America* (Cambridge, MA: MIT Press, 1989), pp. 172–173.

Other Sources:

J.J. Flink, *America Adopts the Automobile, 1895–1910* (Cambridge, MA: MIT Press, 1970).
J.J. Flink, *The Car Culture* (Cambridge, MA: MIT Press, 1975).
R. Lacey, *Ford: The Men and the Machine* (Boston: Little Brown, 1986).
D.L. Lewis. *The Public Image of Henry Ford: An American Folk Hero and his Company* (Detroit: Wayne State University Press, 1976).
A. Nevins and F.E. Hill, *Ford: The Times, the Man, the Company* (New York: Scribner, 1954).
A. Nevins and F.E. Hill, *Ford: Expansion and Challenge, 1915–1933* (New York: Scribner, 1957).
A. Nevins and F.E. Hill, *Ford: Decline and Rebirth, 1933–1962* (New York: Scribner, 1963).
J.B. Rae, *The American Automobile: A Brief History* (Chicago: Chicago University Press, 1965).
J.B. Rae, *The Road and the Car in American Life* (Cambridge, MA: MIT Press, 1971).
E. Rothschild, *Paradise Lost: The Decline of the Auto-Industrial Age* (New York: Random House, 1973).

CHAPTER 12. ELECTROMAGNETIC WAVES

Activity

Have students prepare a report on the current status of the problems of global warming and ozone depletion and the possible solutions to these problems.

Classic Video

"Standing Electromagnetic Waves." Available in VHS and DVD formats with new audio track and sound effects, *Physics: Cinema Classics* (Lexington, KY: Ztek Co.): http://www.ztek.com.

Objectives

With this chapter students are introduced to one of the most important components of classical physics. At the same time, this chapter provides a case study in the development of a physical theory, from hypotheses to theory construction, experimental confirmation, and applications. Section 12.5 offers a survey of some of the important uses of electromagnetic waves, as well as two environmental problems with which they are associated: global warming and the effects of ozone depletion.

Suggestions

Students should be reminded of some of the properties of waves and light (covered in Part One, Chapter 8), as well as such basic optical phenomena as reflection and refraction. Students might further explore the social, economic, and scientific problems associated with some of the contemporary topics and issues raised in this chapter.

Further Reading

G. Cantor, D. Gooding, and F.A.J.L. James, *Michael Faraday* (Amherst, NY: Humanity Books, 1996).

D.E. Fisher and M.J. Fisher, *Tube: The Invention of Television* (New York: Harcourt Brace, 1997).

D. Park, *The Fire within the Eye: A Historical Essay on the Nature and Meaning of Light* (Princeton, NJ: Princeton University Press, 1997).

C. Susskind, *Heinrich Hertz: A Short Life* (San Francisco: San Francisco Press, 1995).

C.E. Swartz and T. Miner, *Teaching Introductory Physics: A Sourcebook* (Woodbury, NY: AIP Press, 1997). Chapter 20.

Web site

Ozone Depletion (Beyond Discovery, Sloan Foundation): http://www.BeyondDiscovery.org.

Technology Insert: Television Technology

Further Reading

Sloan Technology Series Source

D.E. Fisher and M.J. Fisher, *Tube: The Invention of Television* (New York: Harcourt Brace, 1997).

Other Sources:

Technology

A. Abramson, *The History of Television, 1880–1941* (Jefferson, NC: McFarland, 1987).
R. Marshall, *History of Television* (New York: Gallery Books, 1986).
G. Shiers, ed., *Technical Development of Television* (New York: Auio Press, 1977).
J. Wyer, *The Moving Image* (Oxford, UK: Blackwell, 1989).

The Inventors

A. Abramson, *Zworykin: Pioneer of Television, 1880–1941* (Jefferson, NC: McFarland, 1987).
K. Bilby, *The General* (New York: Harper and Row, 1986).
C. Dreher, *Sarnoff: An American Success* (New York: Quadrangle, 1977).
O. Everson, *The Story of Television: The Life of Philo Farnsworth* (New York: Norton, 1949). (Reprinted by New York: Arno Press, 1974.)
E. Farnsworth, *Distant Vision: Romance and Discovery on an Invisible Frontier* (Salt Lake City, UT: Pemberly Kent, 1990).
D.F. Glut and J. Harmon, *The Great Television Heroes* (New York: Doubleday, 1975).
I. Flatrow, *They All Laughed* (New York: HarperCollins, 1992).
E. Lyons, *David Sarnoff* (New York: Harper and Row, 1966).
T. McArthur and P. Waddell, *The Secret Life of John Logie Baird* (London: Hutchinson, 1986).

The Industry

J. Udelson, *The Great Television Race: A History of the American Television Industry 1925–41* (Alabama: University of Alabama Press, 1982).

The Development of Television in America

E. Barnouw, *Tube of Plenty, The Evolution of American Television* (New York: Oxford University Press, 1975).

The Development of Television in Europe

A. Briggs, *The History of Broadcasting in the United Kingdom*, 4 Vols. (Oxford, UK: Oxford University Press, 1961–1979).
R.W. Burns, *British Television: The Formative Years* (London: Peter Peregrinus, 1986).

High Definition and Digital Television

J. Brinkley, *Defining Vision: The Battle for the Future of Television* (New York: Harcourt Brace, 1997).

N. Negroponte, *Being Digital* (New York: Knopf, 1995).

CHAPTER 13. PROBING THE ATOM

Suggested Mini-Laboratory Exploration

- How Do We Know That Atoms Really Exist? The Brownianscope.

Suggested Major Laboratory Exploration

- Avogadro's Number and the Size and Mass of a Molecule.

Demonstration

The effect of a magnetic field on an electron beam can easily be demonstrated by moving a bar magnet slowly toward the stationary beam of an oscilloscope or toward a television or computer monitor displaying a still image. Students are usually astonished that the beam moves perpendicularly to the direction of increasing field intensity. The direction can be predicted using the Lorentz force.

Objectives

This chapter is the first of three chapters that follow the journey inward toward an understanding of the atomic realm. While the first half of this text culminated in relativity theory, this half of the text turns toward atoms, the corresponding contemporary theory of their behavior—quantum mechanics, and areas of physics that have emerged from this work.

Suggestions

Review the material on the electromagnetic spectrum in Section 12.5, pointing out the position of X rays on the spectrum, as well as the change in damaging effects of electromagnetic waves as the frequency increases above the visible range.

The laboratory on Avogardro's number should be preceded by a considerable review of the arithmetic operations using scientific notation.