

BIBLICAL WORLDVIEW SHAPING

in Physics 4th Edition

Is the study of matter in motion just a matter of physical phenomenon?

Physics is possible only because the immaterial God spoke the world and motion into existence. As we examine four worldview themes throughout this product, the following represent the many questions that we will be addressing.

Foundations of Physics

The assumptions and details underlying physics demonstrate the power of the Creator. Secular science, however, approaches physics with disregard of the Creator. Instead of acknowledging God as the ultimate explanation for matter and energy, it claims that man is able to establish principles, assumptions, and observations to stand in authority over the Word of God.

- *How does the second law of thermodynamics relate to a naturalistic worldview and to a biblical worldview?*
- *What makes the magnetosphere evidence for Earth's good design?*

Ch 1	Ch 12	Ch 13	Ch 18	Ch 20	Ch 22	Ch 25
E (1.1.1), E (1.3.1), Ev (1.3.2)	Ev (12.1.2)	Ev (13.3.3)	F (18.1.5)	E (20.1.4)	F (22.1.3)	Ev (25.2.5)

Key

- R — Recall biblical teaching
E — Explain biblical teaching
Ev — Evaluate controversial concepts
F — Formulate a Christian understanding of a controversial concept
A — Apply a Christian understanding to life
- Implementation of the biblical worldview themes in their respective chapters*

Models in Physics

God's creation is so complex and vast that humans must use modeling to explore it. Modeling is a God-given tool for understanding, analyzing, and predicting the activity of God's world. The secular physicist will accept and create models that disregard a Creator and will not allow for a biblical explanation of reality. Model making in these cases is an attempt to be "objective" by assuming a purely material world.

- *How well do the principles of motion model Saturn's system of moons?*
- *How should the Christian explain the existence and use of models in physics if they are not mentioned in the Bible?*
- *How does the development of the quantum theory of energy demonstrate the nature of modeling?*

Ch 1	Ch 2	Ch 5	Ch 7	Ch 10	Ch 15	Ch 18	Ch 20	Ch 21	Ch 24
E (1.1.2)	E (2.2.3)	E (5.1.1), Ev (5.1.5)	F (7.3.4)	F (10.4.4)	E (15.1.4)	Ev (18.2.6)	Ev (20.3.6)	Ev (21.1.4)	F (24.1.4)

Environment and Physics

When God commanded man to subdue and rule over the earth, this subduing and ruling in the work of physics would be done by way of conservation, preservation, and production. To the secular physicist the material world is his origin, purpose, and end. This worldview presses the physicist to treat the world not as a gift from God to be used but as that which must be served.

- *Should Christians support hydroelectric dam construction?*
- *How should a Christian explain climate change, and do proposed solutions fit within a biblical worldview?*
- *How should a Christian respond to technologies that create noise pollution near populated areas?*

Ch 7	Ch 8	Ch 10	Ch 12	Ch 14	Ch 19
F (7.2.4)	Ev (8.3.4)	Ev (10.4.5)	E (12.3.4)	Ev (14.2.4)	F (19.2.4)

Ethics in Physics

Because God made the world, nothing in it, including knowledge, is neutral. Even the study and use of physics affect the world in ethical ways. A secular approach to physics has no grounding ethical principle for determining right and wrong. Without grounding ethical principles, a secular approach to physics must derive its view of right and wrong from human opinion.

- *What is the role of government in civil engineering according to a biblical worldview?*
- *Does society have an obligation to make new technologies available to all?*
- *Should mirrors for geoengineering be used to reduce climate change?*

Ch 1	Ch 2	Ch 3	Ch 4	Ch 6	Ch 9
E (1.1.2)	F (2.2.4)	A (3.3.5)	Ev (4.2.3)	F (6.4.4)	F (9.2.3)
Ch 11	Ch 13	Ch 17	Ch 20	Ch 24	Ch 25
E (11.3.5)	E (13.2.5), F (13.3.4)	F (17.2.5)	F (20.3.7)	E (24.3.4)	F (25.3.5)

Scan this code for a fuller discussion of these themes.



Features of This Textbook

This textbook is for you, and we've designed it to help you learn. Flip through the following pages to see its features, which we believe will help you succeed in physics. In the back of the textbook you will see other features, including an appendix section, glossary, index, and periodic table. We've designed this textbook with you in mind. We hope that it will help you appreciate the wonders of God's creation even more.

1 Chapter Opener
short articles that highlight issues and developments in physics that demonstrate how physics intersects with your life



13.1 The Zeroth and First Laws

As the sun and the freshwater available rise to the surface, we get more and more uncomfortable. But the hotter temperatures affect more than just our comfort; they are likely to be more fatal. Both temperature and humidity can affect cognitive and motor skills. Agriculture, the most important of the crops, livestock, and aquaculture, manufacturing, libraries, and many other facilities rely on cooler temperatures and low humidity to function effectively and to protect their customers and products. Most farmers, sailors, and speed skaters in fact, build weather houses that warm in the summer have killed thousands of people in the United States since its first decades. How can technology help us cope with this continuing problem?

Internal Energy

As far as we have studied, there are two forms of energy—mechanical and thermal. Mechanical energy is a property of objects. Two aspects of mechanical energy are potential and kinetic energy. Potential energy, a kind of work, can be changed to kinetic energy—energy of motion. Total mechanical energy is the sum of the kinetic and potential energy due to the motion and position of physical objects. Just as objects can have both kinetic and potential energy, the particles within an object also have both kinetic and potential energy. The sum of the particle kinetic and potential energies of a substance is called its **internal energy** (U). Because the particles of a substance are constantly moving, they have kinetic energy. Their average kinetic energy is proportional to the temperature of the substance. These particles also have potential energies, but it is extremely complicated to determine the values for establishing these energies. As with mechanical energy, once the internal energy of a system is established or assumed for a given state of the system, only the change in internal energy becomes important. Changes in internal energy (ΔU) are usually much easier to determine than the internal energy values at the beginning and end of a process.

The Zeroth Law of Thermodynamics

We all know that when you place a hot object in contact with a cold object, the cold object becomes warmer and the hot object becomes cooler. Thermal energy flows from the hot object to the cold object, so that the two objects reach the same temperature and there is no net movement of thermal energy; that is, they are in **thermal equilibrium**. When systems are in thermal equilibrium with a third system, then they must be in thermal equilibrium with each other. This is the **zeroth law of thermodynamics**. This law is like the transitive property of mathematics: if $A = B$ and $B = C$, then $A = C$. The law named in honor of Kelvin is more basic than either the first or second law and is foundational to them, but a name is needed to refer to the first two laws that already have names.

Many people often use the word "heat" because it is a common-sense word for transferring thermal energy, which can be transferred in other configurations of energy. The official use of the word "heat" is reserved for the scientific study of thermodynamics.

How do work and heat relate to each other?

QUESTIONS

- How can heat be a form of energy?
- How can heat be transferred?
- How can heat be transferred?
- What is a heat engine?

TERMS

Internal energy—thermal equilibrium, work, law of thermodynamics, heat engine, state system, closed system, isolated system, adiabatic process, thermodynamic process, volume process

ConnectConcepts

As you learned in Chapter 12, the flow of thermal energy is related to many laws. Thermal energy can be used in many ways with thermal energy discussed here.

7

Some objects receive energy and become increasingly hot.

- 2 Essential Question**
the big question that you will learn about in a section
- 3 Key Questions**
the smaller questions that you can ask along the way through a section to help you answer the essential question
- 4 Vocabulary Terms**
the key terms that will be introduced in a section

- 5 ConnectConcepts**
short text connecting the current chapter to previously learned material
- 6 Bold-Faced Terms**
vocabulary terms that you need to know
- 7 Italicized Terms**
terms that will be defined later in the textbook or that are important terms in other scientific fields

case study

FOUCAULT PENDULUM

Do you believe that the earth is flat? In 1851 French physicist Jean-Bernard Léon Foucault set out to prove that it isn't by using a pendulum from the dome of the Pantheon in Paris. The pendulum consisted of a 28 kg iron ball on the end of an approximately 67 m wire. The period of the swinging pendulum was about 31.2 s and would swing about four times each minute.

The pendulum was hung in such a way that only vertical forces were acting on the pendulum. If the earth truly rotated it would move and Foucault's pendulum is that the pendulum's orientation would appear to change. Foucault drew a line on the floor to mark the direction of the pendulum's initial swing and then set the pendulum in motion.

As if the pendulum seemed to follow the line, but eventually the change was noticeable. After eight hours the pendulum was swinging perpendicular to the line. After nearly 24 hours, the pendulum swing was aligned with the line on the floor again. Since only vertical forces acted on the pendulum, Foucault concluded that the pendulum didn't swing through 360° around the iron and the earth rotated around the pendulum.

Questions to Consider

1. Draw the forces and length of the pendulum which is possible?
2. Why do you think Foucault selected the specific mass and length for his pendulum?
3. If Foucault's pendulum demonstrates that the earth is rotating, how does it relate to the pendulum's initial swing to its original alignment in twenty-four hours?

8 Case Studies
opportunities to investigate specific areas in physics to apply what you have learned in a chapter

16 CHAPTER REVIEW

Chapter Summary

16.1 MODELING ELECTRIC FIELDS

- All charged objects have an electric field that radiates out in space around them. Other charged objects within the space will experience an electric force.
- The electric field strength is a vector quantity of the electric force per unit charge. Due to the convention of using a positive test charge, electric fields point away from positive objects and toward negative objects.
- Electric potential energy is the work needed to move a charge to a position within an electric field.
- Electric potential is the electric potential energy per unit charge.

TERMS
electric field
test charge
electric potential energy
electric potential
potential difference

TERMS
capacitor
capacitance
permittivity of free space
permittivity of material

16.2 CAPACITORS

- A capacitor is an electric circuit device for storing charge. It is typically made of two conductors separated by a vacuum or dielectric.
- A dielectric, an insulating material, increases the charge stored on each conductor due to the induced polarization of the dielectric.
- A dielectric increases the capacitance of a capacitor. The dielectric constant is the ratio of the capacitance with the dielectric to the capacitance without the dielectric.
- Capacitance is a measure of the charge that can be stored per unit potential difference.
- The total capacitance of capacitors in parallel is the sum of their capacitances.
- The reciprocal of the total capacitance is equal to the sum of the reciprocals of the individual capacitances for capacitors in series.

TERMS
parallel-plate capacitor

Chapter Review Questions

RECALLING FACTS

1. What would happen for the spatial distribution and amount of the electric force associated with a charge if the graphed values we use to represent it is a degree?
2. What are lines of force?
3. What is electric field strength?
4. Describe a test charge.
5. Describe the direction of an electric field.
6. What is electric potential?
7. What does a capacitor do?
8. What does it mean that a dielectric is polarized? What effect does that have on the electric field within a capacitor?
9. Define capacitance.
10. What is the relationship between the charge stored in a capacitor, the potential difference, and capacitance?
11. How is the capacitance of a capacitor related to the dielectric and materials within it?

UNDERSTANDING CONCEPTS

12. In the diagram at right, in what region is the electric force the strongest? Why?
13. Draw the lines of force surrounding a spherical, negatively charged metal shell.
14. How can an observer not present an electric field?
15. An object with a charge of 1.00 mC is held by two other charges. Which is negative that gives electric field strength at a given distance to have the charge.

16 Chapter 16

9 Chapter Summary
handy statements of the big ideas of the chapter, including vocabulary lists

10 Review Questions
questions at the end of each section and chapter that will have you recall facts, demonstrate your understanding of concepts, and cause you to use critical thinking

11 Mini Labs
short hands-on activities to get you thinking and working like a scientist

12 Career Boxes
information about careers in physics (that could be yours!) that can be followed to wisely use God's world and help people!

13 STEM Connection Boxes
descriptions of how science, technology, engineering, and mathematics (STEM) work together to solve real-world problems

MINI LAB

Changing the Harmonics of a Bottle

The notes played by a musical instrument are produced by vibrating some molecules in the instrument. A soda bottle can be used as an instrument by blowing horizontally across the open top. How can we change the notes played in a bottle?

11 What affects the harmonics of a bottle?

EQUIPMENT

- soda bottles (3)
- water, varying temperatures
- marker



1. What type of instrument do you think the bottle is most similar to? Explain.

Procedure

- Mark each of the bottles at about 1/3, 1/2, and 2/3 the way up the bottle.
- Fill the first bottle to the 1/3 mark with room-temperature water and the other bottles to the 1/2 mark with room water. Then blow across the open neck of each bottle to produce a note. Observe any difference in the pitch.
- What is the molecule that is vibrating?
- Repeat Step 2 but with water at both the 1/2 and the 2/3 marks.

Conclusion

- What was the effect of changing the volume of water in the bottle? Explain.
- What was the effect of changing the water temperature?

Going Further

- Pick an instrument and make comparisons between that instrument and what you observed in the laboratory.

Standing Waves

An interesting application of constructive and destructive interference is called a standing wave, a wave that appears to stand still even though it is actually vibrating. A standing wave is created by vibrating an elastic, and we set it loose in Section 13.1. The object in a string oscillator has to be in phase. To generate a standing wave in a string, the wavelengths of the equal waves must be related to the length of the string. The relationship is

$$\lambda = \frac{2L}{n} \quad (13.4)$$

where L is the length of the string and n is an integer.

284 Chapter 13

EXAMPLE 13.1 Finding an Image Magnification—Diverging Lens

An object 8.00 cm high is 30.0 cm from a diverging lens with a focal length of 20.0 cm. Use the lens equation to determine (a) the position of the image, (b) the height of the image, and (c) the magnification of the image. Then (d) describe the image.

What you know:

$$h_o = 8.00 \text{ cm} \quad f = -20.0 \text{ cm} \quad h_o = 1$$

$$d_o = 30.0 \text{ cm} \quad d_i = ? \quad M = ?$$

a. Write the formula and solve for the unknown.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \quad (\text{Equation 13.2})$$

Plug in known values and evaluate.

$$\frac{1}{-20.0 \text{ cm}} = \frac{1}{30.0 \text{ cm}} + \frac{1}{d_i}$$

$$\frac{1}{d_i} = \frac{1}{-20.0 \text{ cm}} - \frac{1}{30.0 \text{ cm}}$$

$$= \frac{-3.00 - 2.00}{60.0 \text{ cm}}$$

$$= -\frac{5.00}{60.0 \text{ cm}}$$

$$d_i = -12.0 \text{ cm}$$

b. Write the formula and solve for the unknown.

$$M = \frac{h_i}{h_o} \quad (\text{Equation 13.3})$$

Plug in known values and evaluate.

$$M = \frac{h_i}{8.00 \text{ cm}} = \frac{-12.0 \text{ cm}}{30.0 \text{ cm}}$$

$$= -0.400$$

c. Write the formula and solve for the unknown.

$$M = \frac{h_i}{h_o}$$

Plug in known values and evaluate.

$$M = \left(\frac{-12.0 \text{ cm}}{30.0 \text{ cm}} \right) \left(\frac{8.00 \text{ cm}}{8.00 \text{ cm}} \right)$$

$$= -0.320$$

d. Describe the image.

The image is 12.0 cm from the lens on the same side as the object and is 0.320 cm high. It is a virtual, upright, reduced image.

12 CAREERS



SERVING AS AN OPTOMETRIST RESTORING SIGHT


An estimated 2.2 billion people worldwide suffer from some form of vision impairment. People living in the United States may assume

that their eyes are addressed through regular doctor visits and the use of eyeglasses. But the WHO estimates that one billion of the world's population either could have been prevented or have not had the attention. Optometrists around the world work to identify the suffering of those with vision impairments. The field of optometry was initially focused on prescribing and providing contact lenses. Over time the field has expanded to include many aspects of vision, the eye, and medicine that allow us to help people see the world. The Philosophy of Christian Optometry focuses on the aspect of medical ministry work to meet the needs of all.

Optometrists hold a Doctor of Optometry degree, and much of their study involves the optics of the eye as well as the human eye's anatomy. That they work in the diagnosis and treatment of eye ailments. Optometrists use their knowledge of optics to serve others and glorify God.

STEM Connection

science • technology • engineering • mathematics



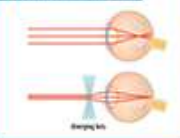
EYEGLASSES

The human eye is an amazing tool designed with an adjustable lens so that it can focus both near and far images. As many of us have learned, one consequence of that fact is that not everyone's eyes are able to properly focus both near and far images. Thankfully, our society has allowed us to use lenses to correct defects in our eyes, as well as in other vision-deficient eyes.

A person who is nearsighted can clearly see objects that are close to her but is unable to focus the image of objects that are farther away. This eye defect is unable to relax, then cannot see sufficiently, so the images of distant objects are focused in front of the retina. A vision specialist can optometrist can provide glasses containing diverging lenses that will slightly spread the rays of light from distant objects. This slight spreading of the rays allows each ray to hit the retina.

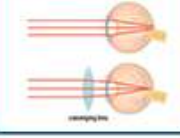
Another person may need reading glasses because he can clearly see objects that are distant but can't focus the image of objects that are nearby. The images of nearby objects are focused behind the retina because the eye lenses are unable to come enough to converge the light quickly enough. In this case, a vision specialist can optometrist can provide glasses containing converging lenses, which start the converging of light so that the eye lenses can focus these rays on the retina.

correcting nearsightedness



diverging lens

correcting farsightedness



converging lens

worldview investigation

SMART GRIDS
Imagine that you are working on a team to research when the power goes out. You can see that your entire neighborhood is out, but the fountains of the town are the only ones that are still on. You see that the outage is affecting your entire town. Then you hear that it is in the state. Over the course of the next few hours, it is evident that the outage covers your state as well as six other states. News agencies are saying that some customers will be without power for days to weeks.
How does this happen, and how can we prevent it? One way is by developing a smart grid of electricity. But what is a smart grid and what can it possibly do?

Goal
Months after the outage that affected your hometown, the US House of Representatives is preparing to debate the funding of a smart grid initiative. Your legislature is asking you to form a committee. Since your state is being impacted by a major power outage, you decide to do some research. Once you have finished, you will write a letter to your representative indicating your support for or opposition to the proposed initiative.

Procedure

1. Research smart grids by doing an internet search using the keywords "developing a smart grid" and "why do we want a smart grid" also research any negative aspects of a smart grid by doing a keyword search for "downside to a smart grid".
2. Prepare your letter, including both positive and negative aspects of a smart grid. Explain from a biblical perspective whether your legislature should vote for or against the measure and why.
3. Share your letter with a Christian or family member and ask for feedback.
4. Review your letter on the basis of the feedback received and turn in your letter.

Conclusion
Our technology-driven world depends on what we call a smart grid. It may be the answer to provide the electricity we need for our ever-growing demand.

14 **Worldview Investigation Boxes**
inquiry-based investigations that help you think through controversial areas of physics through the lens of Scripture

ethics

ELECTRICAL CODES
Electricity is essential to our daily lives, but it can also be dangerous. Each year, hundreds of people die and thousands are injured by electric shock. An estimated 600,000 and 100,000 injuries are caused by electrical outages. Over the years, local, state, and federal agencies have implemented safety standards to address these issues. Each new round of safety codes costs a billion or more dollars of dollars that are passed on to customers.
Imagine that you are having a house built and your contractor has suggested that there are some building codes that are costly to comply with but not very effective at protecting people. He has asked you whether you want to save some money by having the electrician circumvent some of these codes. He tells you that it is your house and that non-compliance won't affect anyone else.

15 **Ethics Boxes**
opportunities to apply a biblical worldview to ethical issues in physics

344 Chapter 10

345

16. How many grams of water could you heat from 0°C to 100°C with the thermal equivalent of the energy used by a 100-W bulb that runs for 1 hr?

17. Consider the circuit below. What is the value of the unknown resistor?

Use the ohm's law at right to answer Question 16.

18. How do you respond to the electrician? Write a four-paragraph response to the proposal from a biblical perspective.

Using Your TEACHER EDITION



Welcome to BJU Press Physics 4th Edition!

Your students are about to discover and explore the incredible richness of the universe that God has created. During this journey students will find that people's views of physics vary drastically, depending on worldview—the overarching narrative that a person uses to see and interpret the world. Everyone has one. It shapes our beliefs and values, and each of us will make choices in life that are based on worldview.

Since physicists all have worldviews, conflicts arise about their interpretations of what they observe. What is the origin of matter and energy? How do we determine the proper use of a new technology? What is our duty in the way that we treat the creation? *Physics* Student Edition 4th Edition helps students grapple with these questions from a biblical standpoint.

Though a good textbook is important, you as the teacher are essential to successful learning. Your job is to guide your students to learn through the lens of the Bible's narrative. Physics class should be a time of discovery for both you and them. Your emphasis on glorifying God by obeying the Creation Mandate and helping other people through science will keep physics exciting and will impact your students. These are the most important lessons that you can teach.

Make this course fit the needs of your students. *Physics* Student Edition and *Physics* Lab Manual both include more material than most teachers will be able to cover in one school year. You decide whether you will spend extra time on a particular topic, a lab activity, or a project.

New to This Edition

If you have used previous editions of *PHYSICS* Student Edition, you will notice some changes in the 4th Edition.

- The writing style, vocabulary, and amount and distribution of content have been refined to better facilitate student learning at a twelfth-grade level.
- The text focuses on big ideas identified by essential questions.
- Each section starts with key questions and a vocabulary list to facilitate prereading of the material. Students will know the important terms to learn and the questions that the section will answer.
- Emphasis has been placed on clearly explaining concepts and demonstrating how problems in physics are solved.
- Each chapter is identified as foundational, key, or enrichment. Foundational chapters are crucial for students to develop a basic understanding of physics. Key chapters are very important and may contain material that appears on standardized tests. Enrichment chapters may be skipped with little adverse effect on students; use them if a significant portion of your class is interested or if you have gifted students who need differentiated instruction.
- Case studies, worldview investigations, STEM connection boxes, and career boxes engage students' interest.
- Expanded examples model the problem-solving process and provide necessary scaffolding for student mastery of the content.
- Every chapter includes a mini lab. These short lab activities reinforce the objectives of the section and generally require less time and fewer materials than the activities in the Lab Manual.
- Ethics boxes found in many chapters present ethical dilemmas related to current fields of physics. Students formulate a biblical understanding of the issues and apply it to those issues. Students are provided with a good deal of support early in the Student Edition and become more independent as they continue through the remainder of the book.
- Each chapter ends with a chapter summary and review that presents in a few brief sentences the primary concepts of each section. This is followed by a set of chapter review questions. The reviews are divided into questions that require students to recall facts, those that compel them to demonstrate a thorough understanding of concepts, and those that require them to apply critical thinking.
- The teaching material consists of teacher notes, background notes, clarifying notes, and differentiated instruction notes with a teaching cycle (see page xxiii). Teacher notes begin with an introductory sentence consisting of a directive to use a **teaching strategy** (in bold) and the purpose of the note itself.

BACKGROUND

Additional Information

Background notes provide extra information that you can share with your students to enhance their learning.

Clarifying Notes

Clarifying notes provide additional information that may facilitate teaching the material.

DIFFERENTIATED INSTRUCTION NOTES

These distinctive notes highlight methods to help all students be successful in the class. These notes will always be in the lower outboard corners of the Teacher Edition margin.

