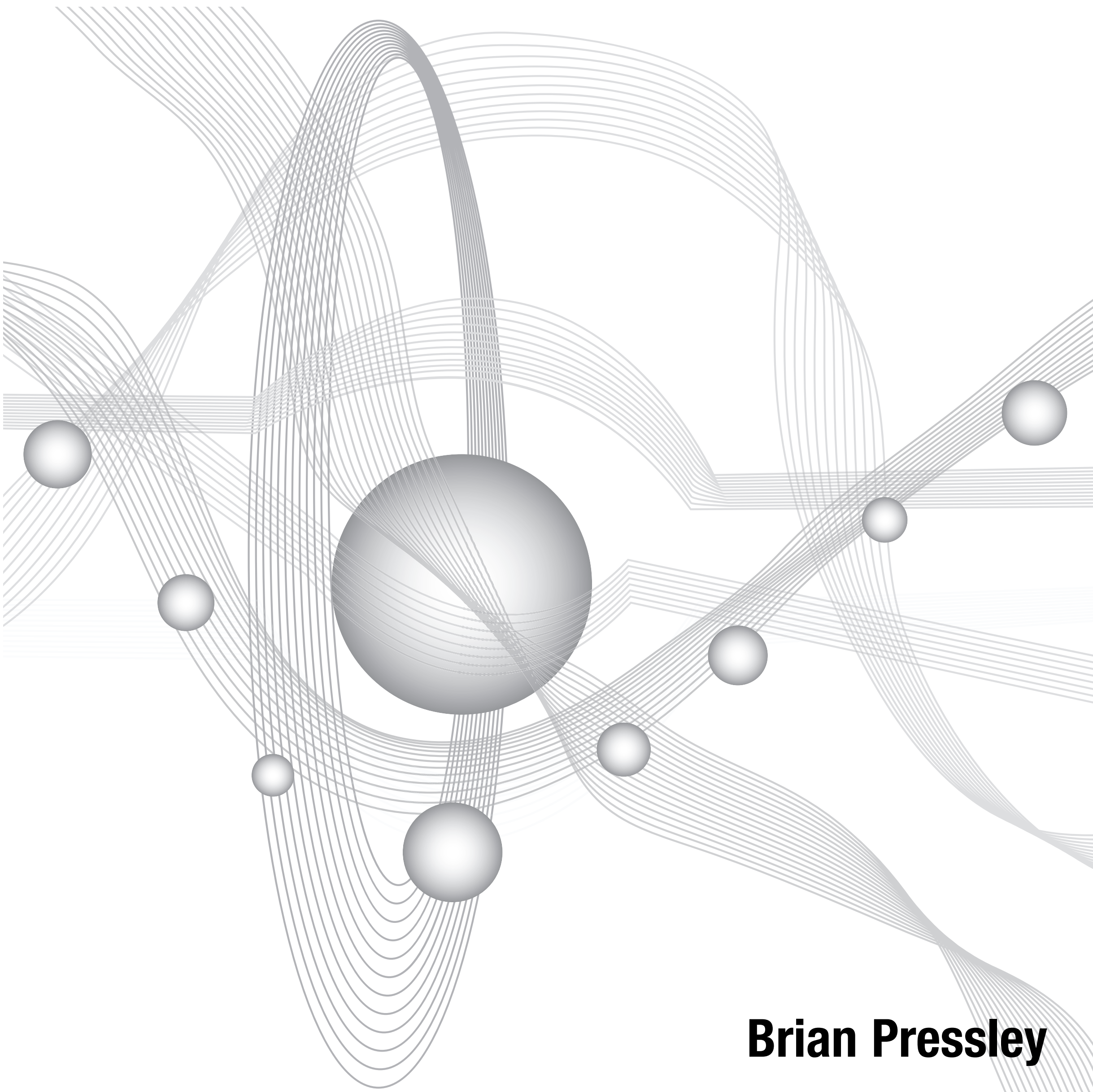
Real-Life Science

PHYSICS



Brian Pressley

WALCH PUBLISHING

Table of Contents

Introduction . . . . *iv*

National Science Education Standards Correlations . . . . *v*

1. What If You Fell Out of an Airplane Without a Parachute? 1
2. How Do the Airbags in Cars Work? 5
3. How Does Bulletproof Glass Work? 8
4. What Would Happen If You Were in an Elevator and the Cable Broke? 11
5. What Are the Long, Straight Clouds Coming from Passenger Jets? 14
6. Why Isn't Normal Air Used in Race-Car Tires? 17
7. How Do Air Conditioners Work? 20
8. What Is a Light Emitting Diode (LED), and How Does It Work? 24
9. What Is a Liquid Crystal Display (LCD), and How Does It Work? 27
10. How Are Movies Put on DVDs? 30
11. What Is a DVR, and How Does It Work? 33
12. How Do Digital Cameras Work? 36
13. How Does a Rechargeable Battery Work? 39
14. How Does a Call Find My Cell Phone? 43
15. How Can So Many Music CDs Fit on a Digital Music Player? 46
16. How Do Microphones and Speakers Work Together? 49
17. Why Do Some Clothes Rapidly Change Color in the Sun? 52
18. Is the Moon Bigger When It's Near the Horizon? 55
19. How Long Can a Human Survive in Outer Space? 59
20. How Do We Know How Much a Planet Weighs? 63
21. How Do Automatic Doors Know When to Open? 66
22. How Does a Microwave Oven Heat Food? 69
23. How Big Is a Nuclear Explosion? 72
24. How Does a One-Way Mirror Work? 75
25. Where Does Static Electricity Come From? 78

Introduction

The *Real-Life Science* series is designed to engage students with topics of high interest that involve places, phenomena, technology, and concepts that they may encounter in their everyday lives. The topics were chosen by professionals in science education, and the National Science Education Standards were used to develop lessons that addressed a number of content standards. Each book in the series has a correlations chart that shows core standards that are addressed by each lesson, as well as other standards that are addressed, but are not the main focus of the lesson.

Using "real-life" examples is a technique that is well supported by the National Science Teaching Standards as well. The list below includes some of the standards that suggest that quality instruction can and should include material that does more than just require students to memorize and repeat basic facts.

Teaching Standard A

Teachers of science plan an inquiry-based science program for their students.

- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

Teaching Standard B

Teachers of science guide and facilitate learning.

- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.

Teaching Standard E

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

- Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.
- Model and emphasize the skills, attitudes, and values of scientific inquiry.

Each book in the *Real-Life Science* series features lessons you can use in your classroom today. Use these engaging lessons to help your students explore the intriguing ways that science is at work all around them.

National Science Education Standards Correlations

C = Core standard   X = Other or optional skill

Title	Physical Science Content Standard B Grades 9–12: Structure of atoms	Physical Science Content Standard B Grades 9–12: Structure and properties of matter	Physical Science Content Standard B Grades 9–12: Chemical reactions	Physical Science Content Standard B Grades 9–12: Motions and forces	Physical Science Content Standard B Grades 9–12: Conservation of energy and increase in disorder	Physical Science Content Standard B Grades 9–12: Interactions of energy and matter	Science and Technology Content Standard E Grades 9–12: Understandings about science and technology	Science in Personal and Social Perspectives Content Standard F Grades 9–12: Personal and community health
1. What If You Fell Out of an Airplane Without a Parachute?				C	X			X
2. How Do the airbags in Cars Work?			X	X		X	C	
3. How Does Bulletproof Glass Work?	X	C		C	X		X	X
4. What Would Happen If You Were in an Elevator and the Cable Broke?				C			X	X
5. What Are the Long, Straight Clouds Coming from Passenger Jets?			C		X			
6. Why Isn't Normal Air Used in Race-Car Tires?		X		C			X	X
7. How Do Air Conditioners Work?					C		X	
8. What Is a Light Emitting Diode (LED), and How Does It Work?	X	X				C	X	
9. What Is a Liquid Crystal Display (LCD), and How Does It Work?		X				C	C	
10. How Are Movies Put on DVDs?		X				C	C	
11. What Is a DVR, and How Does It Work?		X				C	C	
12. How Do Digital Cameras Work?		X				C	C	
13. How Does a Rechargeable Battery Work?		X	C		X	X	X	

National Science Education Standards Correlations

C = Core standard X = Other or optional skill

Title	Physical Science Content Standard B Grades 9–12: Structure of atoms	Physical Science Content Standard B Grades 9–12: Structure and properties of matter	Physical Science Content Standard B Grades 9–12: Chemical reactions	Physical Science Content Standard B Grades 9–12: Motions and forces	Physical Science Content Standard B Grades 9–12: Conservation of energy and increase in disorder	Physical Science Content Standard B Grades 9–12: Interactions of energy and matter	Science and Technology Content Standard E Grades 9–12: Understandings about science and technology	Science in Personal and Social Perspectives Content Standard F Grades 9–12: Personal and community health
14. How Does a Call Find My Cell Phone?						C	C	
15. How Can So Many Music CDs Fit on a Digital Music Player?		X				C	C	
16. How Do Microphones and Speakers Work Together?						C	C	
17. Why Do Some Clothes Rapidly Change Color in the Sun?	X	C			X	X	X	
18. Is the Moon Bigger When It's Near the Horizon?				X		X		
19. How Long Can a Human Survive in Outer Space?		X				X	X	C
20. How Do We Know How Much a Planet Weighs?				C			X	
21. How Do Automatic Doors Know When to Open?				X		X	C	
22. How Does a Microwave Oven Heat Food?						C	X	X
23. How Big Is a Nuclear Explosion?					X	C	X	X
24. How Does a One-Way Mirror Work?						C	X	
25. Where Does Static Electricity Come From?	C					X		

National Research Council. *National Science Education Standards*. Washington, DC: National Academy Press, 1996.

National Research Council. "National Science Education Standards." http://books.nap.edu/readingroom/books/nses/6e.html#csa912.

1. What If You Fell Out of an Airplane Without a Parachute?

Topics

gravity, terminal velocity, air resistance

Goal

To help students understand the various forces and circumstances that affect the behavior of a falling body, in particular a human body, as it falls from an airplane

Context

Students have continually increasing access to a wide variety of extreme sports, either through actual participation, print media, video, or video games. As a consequence, they are interested in unusual events in physics and some of the extreme conditions that the human body can withstand.

Teaching Notes

- Demonstrate the effect air resistance has on a falling body by comparing the fall rate of two objects, perhaps a crumpled piece of paper and a flat piece of paper of the same mass.
- Clarify the nature of terminal velocity. Students need to understand that the object is still falling; it is simply no longer accelerating.
- Ask students to share examples of falls they have taken or have heard about that were survived with little or no injury. Ask for examples they have heard of that resulted in serious injury, particularly falls that happened from low heights.

Extension Activity

Ask students to find examples of people surviving a fall out of an airplane. Have them be sure to include the circumstances that allowed the falling person to survive. Make a list with the class of the various circumstances that might protect them should they ever find themselves falling without a parachute.

Answer Key

1. a
2. d
3. b
4. c
5. c
6. d
7. b
8. a
9. d
10. d

Name ______________________ Date ______________________

1. What If You Fell Out of an Airplane Without a Parachute?

Explanation

Of course, little experimentation has been done on humans to determine the answer to this question. With that in mind, we are left with what we have learned from people who have fallen from planes by accident, or were left falling without the benefit of a parachute during a skydiving mishap.

The short answer is: It would be very bad. An object accelerates at around 9.8 m/s^2 (32 ft/s^2) due to the pull of gravity near Earth's surface. Even with air resistance factored in, a person will reach terminal velocity in 10 to 20 seconds, depending on the altitude from which he or she starts falling. In this case, terminal velocity is the highest speed a person will reach before the effects of air resistance keep the person from accelerating any more. For most people, this speed is somewhere around 193 km/h (120 mph). Speed does depend on the angle of the falling body, weight, and the aerodynamics of the clothing the person is wearing.

The end result of the fall depends on the material landed on. The result can be anything from cuts, scrapes, and bruises, to severe injury or death. Falls from as low as simply standing on the ground have been fatal under the right conditions. Most falls in excess of 15 meters (about 50 feet) have a high chance of being lethal. People have survived falling from airplanes from a variety of altitudes, including as high as 6,100 meters (20,000 feet). They have survived by landing in or on things such as water, thick vegetation, trees, freshly plowed ground, sand, swamps, haystacks, power lines, car roofs, awnings, deep snow, and slanted surfaces.

Some people who have survived falls from great heights have done so in the wreckage or part of a plane that was damaged or failed in flight. Some were entangled in a partially opened parachute or clung to a second person whose parachute deployed properly. Some were even in the remains of a crashing hot-air balloon.

Name ______________________________ Date ______________________

assessment page

1. What If You Fell Out of an Airplane Without a Parachute?

Circle the letter of the best choice to complete each sentence.

1. The acceleration due to gravity at Earth's surface is _____.

   a. 9.8 m/s^2
   b. 9.8 m^2/s
   c. 32 m/s^2
   d. 32 m^2/s

2. It generally takes a skydiver _____ to reach terminal velocity.

   a. 5 to 8 seconds
   b. 5 to 8 minutes
   c. 10 to 20 minutes
   d. 10 to 20 seconds

3. The highest speed a falling object reaches before it stops accelerating due to air resistance is called _____.

   a. maximum velocity
   b. terminal velocity
   c. maximum speed
   d. terminal speed

4. Terminal velocity for the average person is around _____.

   a. 193 mph
   b. 120 km/h
   c. 193 km/h
   d. 120 m/s

5. The terminal velocity of a falling object is not affected by _____.

   a. the weight of the object
   b. the shape of the object
   c. the color of the object
   d. gravity

(continued)

Name ______________________________ Date ______________________

assessment page

1. What If You Fell Out of an Airplane Without a Parachute?

6. A possible result of falling from a plane without a parachute is _____.

   a. scrapes
   b. broken bones
   c. death
   d. all of the above

7. The highest altitude a person has survived falling from without a parachute is _____.

   a. 9,500 meters
   b. 6,100 meters
   c. 8,900 meters
   d. 1,600 meters

8. If you fell from an airplane without a parachute, _____ would provide a relatively safe landing location.

   a. thick vegetation
   b. concrete
   c. a brick building
   d. a highway

9. Falls in excess of _____ are often lethal.

   a. 0 meters
   b. 5 meter
   c. 10 meters
   d. 15 meters

10. Things to try and land on if you fall out of an airplane include _____.

    a. car roof
    b. deep snow
    c. sand
    d. all of the above

13. How Does a Rechargeable Battery Work?

Topics

batteries, reversible reactions, energy

Goal

To explain a simple example of how batteries can be recharged

Context

Students have a large variety of electronic devices (laptops, digital music players, portable DVD players, and so forth) that have rechargeable batteries. Although this lesson doesn't address every kind of battery ever made, it gives a simple model that can be used to describe how many kinds of batteries are recharged.

Teaching Notes

- Explain that there are a wide variety of batteries, and that not all kinds are rechargeable.
- Clarify that not all batteries contain acids like car batteries do. Most students will think that all batteries contain acids, while in truth, many contain strong bases. Modern batteries such as lithium-ion batteries can have solid or liquid electrolyte phases that don't readily conform to simple definitions of acid or base.

Extension Activity

Have students research some of the dangers of recharging various kinds of batteries. Have them find out what kinds of recalls have happened with batteries and what prompted the recalls. Be sure that students understand what can happen if you try to recharge a battery that is not rechargeable.

Answer Key

[illegible]

Name ______________________________ Date ____________________

13. How Does a Rechargeable Battery Work?

Explanation

There are a wide variety of batteries, so let's narrow the discussion down to a simple wet-cell battery such as a car battery. In some types of chemical reactions, chemical A mixes with chemical B to form chemicals C and D. Written as a chemical reaction, you might think of it as the following:

$A + B \rightarrow C + D$

Some reactions move in only one direction under "normal" conditions. But some reactions can be forced to go "backwards" from the most common way they behave. This type of reaction is written with a two-headed arrow to show it is a reversible reaction. Such a reaction is written as follows:

$A + B \leftrightarrow C + D$

In some types of reactions, however, one of the products is electrons. This type of reaction will not run backwards under "normal" conditions. This is the case in the following reaction:

$A + B \rightarrow C + \text{electrons}$

In a regular battery, a chemical reaction takes place in which two chemicals react and form other chemicals and an excess of electrons. These electrons collect at the negative terminal of the battery. When a circuit is completed, the electrons are free to flow in the form of electricity. Eventually chemicals A and B are used up, and the battery weakens or dies.

A rechargeable battery is recharged using an outside electrical source. What is happening, in terms of the reactions mentioned above, is that the reaction is reversible and can be forced into moving backwards:

$A + B \leftrightarrow C + \text{electrons}$

Look at the reaction written a different way:

$\text{electrons (energy in from an electric outlet)} + C \rightarrow A + B$

You can see that the addition of energy in the form of electricity has forced the reaction to run backwards, causing chemicals A and B to reform. This process isn't perfect, however. Side reactions may cause chemicals (E, F, G, H, and so forth) to form that are not chemicals that were in the battery originally. Eventually, even adding electricity back to the battery won't reform enough of chemicals A and B for the battery to work.

Name ______________________________ Date ____________________

assessment page

13. How Does a Rechargeable Battery Work?

Circle the letter of the best choice to complete each sentence.

1. The reaction A + B $\rightarrow$ C + D _____.
   a. represents chemicals C and D reacting to form chemicals A and B
   b. represents chemicals A and D reacting to form chemicals C and B
   c. is reversible
   d. represents chemicals A and B reacting to form chemicals C and D

2. The reaction A + B $\leftrightarrow$ C + D _____.
   a. is reversible
   b. represents chemicals A and D reacting to form chemicals C and B
   c. is not reversible
   d. represents chemicals A and C reacting to form chemicals B and D

3. The reaction A + B $\rightarrow$ C + electrons _____.
   a. is reversible
   b. represents excess electrons being produced
   c. represents chemical C reacting with electrons to form chemicals A and B
   d. cannot happen

4. When a battery is not part of a circuit, electrons _____.
   a. collect at the positive terminal of the battery
   b. collect outside of the battery
   c. will not collect at either terminal of the battery
   d. collect at the negative terminal of the battery

5. When chemicals A and B are used up, _____.
   a. a battery weakens or dies
   b. a battery gets stronger
   c. a battery is at half capacity
   d. a battery has only one hour of power left

(continued)

13. How Does a Rechargeable Battery Work?

6. The reaction electrons + C $\rightarrow$ A + B represents _____.

   a. a battery being run down
   b. a reversible reaction
   c. a battery being recharged
   d. the formation of chemical C

7. Side reactions _____.

   a. double the strength of a battery
   b. form chemicals that are not desired
   c. recharge a battery
   d. create an excess of electrons in a battery

8. When chemicals A and B can no longer be reformed, _____.

   a. a battery is at half capacity
   b. a battery gets stronger
   c. a battery cannot be recharged
   d. a battery is fully recharged

9. Rechargeable batteries are recharged using ______.

   a. chemicals A and B
   b. an outside energy source
   c. in internal energy source
   d. chemicals A and C

10. A reaction that can happen in both directions is called ______.

   a. rechargeable
   b. irrechargeable
   c. irreversible
   d. reversible

24. How Does a One-Way Mirror Work?

Topics

mirrors, front-silvering, back-silvering, reflection

Goal

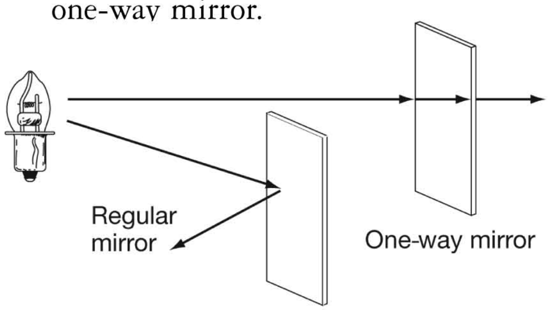
To clarify the difference between a conventional mirror and a one-way mirror

Context

One-way mirrors figure prominently in a number of movies and television shows about crime. Sometimes they are portrayed accurately, and sometimes they are not. This lesson is designed to explain how one-way mirrors work and what their limitations are.

Teaching Notes

- Ask students to talk about the various places where they have seen one-way mirrors and what they were being used for.
- Clarify that one-way mirrors will not work between two equally well-lit rooms.
- Draw a diagram showing light reflecting from a regular mirror and then compare it to a drawing of light being partially transmitted through a one-way mirror.



Extension Activity

If possible, obtain a one-way mirror and show students that it will not work with equal lighting on both sides. If you cannot get a one-way mirror, some regular CDs will act like a one-way mirror, provided there aren't too many images or a label on the top surface.

Answer Key

[illegible]

Name ______________________ Date ______________

24. How Does a One-Way Mirror Work?

Explanation

The first question to answer is: How does any mirror work? There are a number of ways to make a mirror. Early mirrors were simply made of flat metal surfaces that had been highly polished. Modern mirrors are generally made in one of two ways. They are silvered, which means coated with a thin layer of metal. There are front-silvered mirrors and back-silvered mirrors. A front-silvered mirror consists of a piece of material that has a thin film of metal, often aluminum or silver, on the front of the mirror. The metal is usually sealed with a very thin coating of transparent material to keep the metal from corroding. This kind of mirror is used in devices such as telescopes to cut down on unwanted reflection from the glass that is at the front of a back-silvered mirror.

A back-silvered mirror also has a thin coating of aluminum or silver, but the coating is usually painted over with some kind of very dark sealant or paint. You can see the difference between a front-silvered mirror and a back-silvered mirror by simply putting your finger up against the surface. In a front-silvered mirror, your finger will appear to touch the reflection. In a back-silvered mirror, you will see that there is a thin space between the finger and the reflection that is the thickness of the glass.

A one-way mirror is half-silvered. Instead of the glass surface being coated completely with aluminum or silver so that no light gets through, the one-way mirror is coated with a film of metal that is only a few molecules thick. This allows for some of the light to pass through and for some of the light to be reflected. As you may have seen on television, one-way mirrors are often used for security reasons, such as in a bank or an interrogation room. The side where the person is being interviewed is kept bright so that a lot of light reflects back into the room. This gives the one-way mirror the appearance of being a regular mirror on the bright side. The other side, perhaps where the police are watching, is kept dark so that very little light is available to go through the half-silvered surface. This effect can be seen on a house with screens over the windows. When sunlight shines directly on the screens, it is very hard to see into the house. However, the people inside can still see out easily. And just as you can see in through the screen at night when it's dark outside and light inside, a person could see into the observation room if the observation room was bright and the interrogation room was dark.

Name ______________________ Date ______________________

assessment page

24. How Does a One-Way Mirror Work?

Answer the following questions.

1. What were early mirrors made from?

2. Where is aluminum applied to a front-silvered mirror?

3. What kind of material is used to seal a front-silvered mirror? Why is this material used?

4. Where are front-silvered mirrors used?

5. Where is aluminum applied to a back-silvered mirror?

6. How is a one-way mirror silvered?

7. How thick is the silvering coating on a one-way mirror?

8. How must the brightness in the two rooms on either side of the one-way mirror compare for the mirror to work properly?