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Energy, Waves and Light

John
Jean Brainard, Ph.D.

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AUTHORS
John
Jean Brainard, Ph.D.

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Contents

CHAPTER 1 Energy

- Define energy.
- Give the SI unit for energy.
- Identify different forms of energy.

These young children are very active. They seem to be brimming with energy. You probably know that lots of things have energy—from batteries to the sun. But do you know what energy is? Read on to find out.

Defining Energy

Energy is defined in science as the ability to move matter or change matter in some other way. Energy can also be defined as the ability to do work, which means using force to move an object over a distance. When work is done, energy is transferred from one object to another. For example, when the boy in the **Figure** 1.1 uses force to swing the racket, he transfers some of his energy to the racket.

Q: It takes energy to play tennis. Where does this boy get his energy?

A: He gets energy from the food he eats.

SI Unit for Energy

Because energy is the ability to do work, it is expressed in the same unit that is used for work. The SI unit for both work and energy is the joule (J), or Newton • meter (N • m). One joule is the amount of energy needed to apply a force of 1 Newton over a distance of 1 meter. For example, suppose the boy in the **Figure** 1.1 applies 20 Newtons of force to his tennis racket over a distance of 1 meter. The energy needed to do this work is 20 N •m, or 20 J.

FIGURE 1.1

Energy Has Many Forms

If you think about different sources of energy—such as batteries and the sun—you probably realize that energy can take different forms. For example, when the boy swings his tennis racket, the energy of the moving racket is an example of mechanical energy. To move his racket, the boy needs energy stored in food, which is an example of chemical energy. Other forms of energy include electrical, thermal, light, and sound energy. The different forms of energy can also be classified as either kinetic energy or potential energy. Kinetic energy is the energy of moving matter. Potential energy is energy that is stored in matter. You can learn more about the different forms of energy at this URL: http://www.eia.gov/kids/energy.cfm?page=about_forms_of_energy-basics

For an animation showing the different forms of energy used to ride a bike, go to this URL: http://www.childrensuniversity.manchester.ac.uk/interactives/science/energy/what-is-energy/

Q: Is the chemical energy in food kinetic energy or potential energy?

A: The chemical energy in food is potential energy. It is stored in the chemical bonds that make up food molecules. The stored energy is released when we digest food. Then we can use it for many purposes, such as moving (mechanical energy) or staying warm (thermal energy).

Q: What is an example of kinetic energy?

A: Anything that is moving has kinetic energy. An example is a moving tennis racket.

Summary

- Energy is defined in science as the ability to move matter or change matter in some other way. Energy can also be defined as the ability to do work.
- The SI unit for energy as well as work is the joule (J), or Newton • meter (N • m).
- Energy exists in different forms, such as mechanical energy and chemical energy. Most forms of energy can also be classified as either kinetic energy or potential energy.

Vocabulary

- **energy**: Ability to cause changes in matter, or ability to do work.

Practice

At the following URL, unscramble the letters to identify different forms of energy. http://www.learnaboutenergy.org/projects/energypuzzles/puzzle4.html

Review

1. How is energy defined in science?
2. What is the SI unit for energy?
3. Name two forms that energy may take.
4. Which type of energy is the energy of a moving tennis ball? Is it kinetic energy or potential energy?

References

1. . . used under license from shutterstock.com

Chapter 2 Kinetic Energy

- Define kinetic energy.
- Show how to calculate the kinetic energy of a moving object.

What could these four photos possibly have in common? Can you guess what it is? All of them show things that have kinetic energy.

Defining Kinetic Energy

Kinetic energy is the energy of moving matter. Anything that is moving has kinetic energy—from atoms in matter to stars in outer space. Things with kinetic energy can do work. For example, the spinning saw blade in the photo above is doing the work of cutting through a piece of metal.

Calculating Kinetic Energy

The amount of kinetic energy in a moving object depends directly on its mass and velocity. An object with greater mass or greater velocity has more kinetic energy. You can calculate the kinetic energy of a moving object with this equation:

Kinetic Energy (KE) $= \frac{1}{2}$mass $*$ velocity^2

This equation shows that an increase in velocity increases kinetic energy more than an increase in mass. If mass doubles, kinetic energy doubles as well, but if velocity doubles, kinetic energy increases by a factor of four. That's because velocity is squared in the equation.

Let's consider an example. The **Figure** 2.1 shows Juan running on the beach with his dad. Juan has a mass of 40 kg and is running at a velocity of 1 m/s. How much kinetic energy does he have? Substitute these values for mass and velocity into the equation for kinetic energy:

$KE = \frac{1}{2} * 40kg * (1\frac{m}{s})^2 = 20kg * \frac{m^2}{s^2} = 20N * m$, or $20J$

Notice that the answer is given in joules (J), or N • m, which is the SI unit for energy. One joule is the amount of energy needed to apply a force of 1 Newton over a distance of 1 meter.

FIGURE 2.1

What about Juan's dad? His mass 80 kg, and he's running at the same velocity as Juan (1 m/s). Because his mass is twice as great as Juan's, his kinetic energy is twice as great:

$KE = \frac{1}{2} * 80kg * (1\frac{m}{s})^2 = 40kg * \frac{m^2}{s^2} = 40N * m$, or $40J$

Q: What is Juan's kinetic energy if he speeds up to 2 m/s from 1 m/s?

A: By doubling his velocity, Juan increases his kinetic energy by a factor of four:

$KE = \frac{1}{2} * 40kg * (2\frac{m}{s})^2 = 80kg * \frac{m^2}{s^2} = 80N * m$, or $80J$

Review how kinetic energy is related to mass and velocity by watching this cartoon: http://www.schooltube.com/video/faddf7cb14ade293baad/

Summary

- Kinetic energy (KE) is the energy of moving matter. Anything that is moving has kinetic energy.
- The amount of kinetic energy in a moving object depends directly on its mass and velocity. It can be calculated with the equation: $KE = \frac{1}{2} mass * velocity^2$.

Vocabulary

- **kinetic energy**: Energy of moving matter.

Practice

At the following URL, review kinetic energy and how to calculate it. Then take the quiz at the bottom of the Web page. Be sure to check your answer. http://www.physicsclassroom.com/class/energy/u5l1c.cfm

Review

1. What is kinetic energy?
2. The kinetic energy of a moving object depends on its mass and its
   a. volume.
   b. velocity.
   c. distance.
   d. acceleration.
3. The bowling ball in the **Figure** 2.2 is whizzing down the bowling lane at 4 m/s. If the mass of the bowling ball is 7 kg, what is its kinetic energy?

FIGURE 2.2

References

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2. . . Used Under License from Shutterstock.com

CHAPTER 3 Potential Energy

- Define potential energy.
- Show how to calculate gravitational potential energy.
- Describe elastic potential energy.
- Identify other forms of potential energy.

This diver is standing at the end of the diving board, ready to dive. After she dives and is falling toward the water, she'll have kinetic energy, or the energy of moving matter. But even as she stands motionless high above the water, she has energy. Do you know why?

Stored Energy

The diver has energy because of her position high above the pool. The type of energy she has is called potential energy. **Potential energy** is energy that is stored in a person or object. Often, the person or object has potential energy because of its position or shape.

Q: What is it about the diver's position that gives her potential energy?

A: Because the diver is high above the water, she has the potential to fall toward Earth because of gravity. This gives her potential energy.

Gravitational Potential Energy

Potential energy due to the position of an object above Earth's surface is called gravitational potential energy. Like the diver on the diving board, anything that is raised up above Earth's surface has the potential to fall because of gravity. You can see other examples of people with gravitational potential energy in the **Figure** 3.1 and 3.2. You can also watch a cartoon introduction to gravitational potential energy by playing video #10 at this URL: http://www.animatedscience.co.uk/flv/

FIGURE 3.1

FIGURE 3.2

Gravitational potential energy depends on an object's weight and its height above the ground. It can be calculated with the equation:

Gravitational potential energy (GPE) = weight x height

Consider the little girl on the sled, pictured in the **Figure** 3.1. She weighs 140 Newtons, and the top of the hill is 4 meters higher than the bottom of the hill. As she sits at the top of the hill, the child's gravitational potential energy is:

GPE = 140 N x 4 m = 560 N • m

Notice that the answer is given in Newton • meters (N • m), which is the SI unit for energy. A Newton • meter is the energy needed to move a weight of 1 Newton over a distance of 1 meter. A Newton • meter is also called a joule (J).

Q: The gymnast on the balance beam pictured in the **Figure** 3.2 weighs 360 Newtons. If the balance beam is 1.2 meters above the ground, what is the gymnast's gravitational potential energy?

A: Her gravitational potential energy is:

GPE = 360 N x 1.2 m = 432 N • m, or 432 J

Elastic Potential Energy

Potential energy due to an object's shape is called elastic potential energy. This energy results when an elastic object is stretched or compressed. The farther the object is stretched or compressed, the greater its potential energy is. A point will be reached when the object can't be stretched or compressed any more. Then it will forcefully return to its original shape.

Look at the pogo stick in the **Figure** 3.3. Its spring has elastic potential energy when it is pressed down by the boy's weight. When it can't be compressed any more, it will spring back to its original shape. The energy it releases will push the pogo stick—and the boy—off the ground. You can see how a pogo stick spring compresses and then returns to its original shape in the animation at this URL:

http://en.wikipedia.org/wiki/File:Pogoanim.gif

Q: The girl in the **Figure** 3.4 is giving the elastic band of her slingshot potential energy by stretching it. She's holding a small stone against the stretched band. What will happen when she releases the band?

A: The elastic band will spring back to its original shape. When that happens, watch out! Some of the band's elastic potential energy will be transferred to the stone, which will go flying through the air.

Other Forms of Potential Energy

All of the examples of potential energy described above involve movement or the potential to move. The form of energy that involves movement is called mechanical energy. Other forms of energy also involve potential energy, including chemical energy and nuclear energy. Chemical energy is stored in the bonds between the atoms of compounds. For example, food and batteries both contain chemical energy. Nuclear energy is stored in the nuclei of atoms because of the strong forces that hold the nucleus together. Nuclei of radioactive elements such as uranium are unstable, so they break apart and release the stored energy.

Summary

- Potential energy is energy that is stored in a person or object.
- Gravitational potential energy is due to the position of an object above Earth's surface. The object has the potential to fall due to gravity. Gravitational potential energy depends on an object's weight and its height

FIGURE 3.3

FIGURE 3.4

above the ground (GPE = weight x height).

- Elastic potential energy is due to an object's shape. It results when an elastic object is stretched or compressed. The more it is stretched or compressed, the greater its elastic potential energy is.
- Chemical energy and nuclear energy are other forms of potential energy.

Vocabulary

- **potential energy**: Stored energy an object has because of its position or shape.

Practice

Do the animation at the following URL, and then answer the questions below.

http://www.classzone.com/books/ml_science_share/vis_sim/mem05_pg69_potential/mem05_pg69_potential.html

1. Which paint can has greater potential energy after the painter carries it up the ladder? Why is this can's potential energy greater?
2. How could the painter give the other can more potential energy?

Review

1. What is potential energy?
2. Compare and contrast gravitational and elastic potential energy, and give an example of each.
3. The diver on the diving board in the opening picture weighs 500 Newtons. The diving board is 5 meters above the ground. What is the diver's gravitational potential energy?
4. Why does food have potential energy?

References

1. . . Used under license from Shutterstock.com
2. . . Used under license from Shutterstock.com
3. [Flickr: lobo235]. . CC-BY 2.0
4. . . Used under License from Shutterstock

CHAPTER 4 Energy Conversion

- Define energy conversion.
- Give examples of energy changing from one form to another.
- Describe energy changes between kinetic and potential energy.

Sari and Daniel are spending a stormy Saturday afternoon with cartons of hot popcorn and a spellbinding 3-D movie. They are obviously too focused on the movie to wonder where all the energy comes from to power their weekend entertainment. They'll give it some thought halfway through the movie when the storm causes the power to go out!

Changing Energy

Watching movies, eating hot popcorn, and many other activities depend on electrical energy. Most electrical energy comes from the burning of fossil fuels, which contain stored chemical energy. When fossil fuels are burned, the chemical energy changes to thermal energy and the thermal energy is then used to generate electrical energy. These are all examples of energy conversion. **Energy conversion** is the process in which one kind of energy changes into another kind. When energy changes in this way, the energy isn't used up or lost. The same amount of energy exists after the conversion as before. Energy conversion obeys the law of conservation of energy, which states that energy cannot be created or destroyed.

How Energy Changes Form

Besides electrical, chemical, and thermal energy, some other forms of energy include mechanical and sound energy. Any of these forms of energy can change into any other form. Often, one form of energy changes into two or more different forms. For example, the popcorn machine below changes electrical energy to thermal energy. The thermal energy, in turn, changes to both mechanical energy and sound energy. You can read the **Figure** 4.1 how these changes happen. You can see other examples of energy changing form at this URL: http://fi.edu/guide/hughes/energychangeex.html

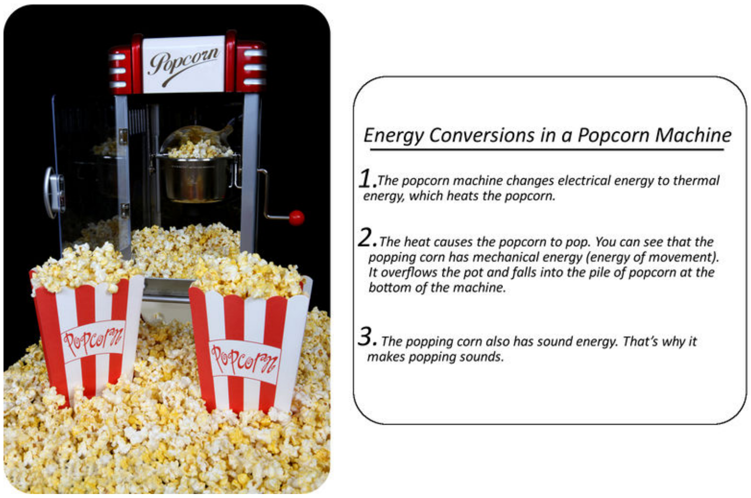

FIGURE 4.1

Kinetic-Potential Energy Changes

Mechanical energy commonly changes between kinetic and potential energy. Kinetic energy is the energy of moving objects. Potential energy is energy that is stored in objects, typically because of their position or shape. Kinetic energy can be used to change the position or shape of an object, giving it potential energy. Potential energy gives the object the potential to move. If it does, the potential energy changes back to kinetic energy.

That's what happened to Sari. After she and Daniel left the theater, the storm cleared and they went to the pool. That's Sari in the **Figure** 4.2 coming down the water slide. When she was at the top of the slide, she had potential energy. Why? She had the potential to slide into the pool because of the pull of gravity. As she moved down the slide, her potential energy changed to kinetic energy. By the time she reached the pool, all the potential energy had changed to kinetic energy.

FIGURE 4.2

Q: How could Sari regain her potential energy?

A: Sari could climb up the steps to the top of the slide. It takes kinetic energy to climb the steps, and this energy would be stored in Sari as she climbed. By the time she got to the top of the slide, she would have the same amount of potential energy as before.

A roller coaster is another fun example of changes between kinetic and potential energy. Watch the roller coaster animation at the URL below to see the energy changes. Notice how the roller coaster's total energy (kinetic energy + potential energy) does not change.

http://physiquecollege.free.fr/physics_chemistry_middle_high_secondary_grammar_school_higher_education_academy_co.uk.us.en/mechanics_forces_gravitation_energy_interactive/energy_potental_kinetic_mechanical.htm

Q: Can you think of other fun examples of energy changing between kinetic and potential energy?

A: Playground equipment such as swings, slides, and trampolines involve these changes.

Summary

- Energy conversion is the process in which energy changes from one form or type to another. Energy is always conserved in energy conversions.
- Different forms of energy—such as electrical, chemical, and thermal energy—often change to other forms of energy.
- Mechanical energy commonly changes back and forth between kinetic and potential energy.

Vocabulary

- **energy conversion**: Process in which energy changes from one type or form to another.

Practice

You can check your understanding of how energy changes form by doing the quizzes at these URLs:

- http://www.think-energy.co.uk/ThinkEnergy/11-14/activities/EnergyTrans2.aspx
- http://www.poweringourfuture.com/students/energy/2.html

Review

1. Define energy conversion.
2. Relate energy conversion to the law of conservation of energy.
3. Describe an original example of energy changing from one form to two other forms.
4. Explain how energy changes back and forth between kinetic and potential energy when you jump on a trampoline. Include a sketch to help explain the energy conversions.

References

1. Stephen Coburn. . Used under license from Shutterstock.com
2. . . Used under license from Shutterstock.com

Chapter 5 Thermal Energy

- Define thermal energy.
- Relate thermal energy to temperature and mass.

This unusual landscape is found in the hottest place in the U.S.: Death Valley, California. The temperature of the air near the ground can be as high as 57 °C (134 °F)—and that's in the shade (if you can find any)! The temperature of the sand in the baking sun can be much higher. If you were to walk barefoot on the hot sand, it would burn your feet. The air and sand in Death Valley have a lot of thermal energy.

What Is Thermal Energy?

Why do the air and sand of Death Valley feel so hot? It's because their particles are moving very rapidly. Anything that is moving has kinetic energy, and the faster it is moving, the more kinetic energy it has. The total kinetic energy of moving particles of matter is called **thermal energy**. It's not just hot things such as the air and sand of Death Valley that have thermal energy. All matter has thermal energy, even matter that feels cold. That's because the particles of all matter are in constant motion and have kinetic energy.

Thermal Energy, Temperature, and Mass

Thermal energy and temperature are closely related. Both reflect the kinetic energy of moving particles of matter. However, **temperature** is the *average* kinetic energy of particles of matter, whereas thermal energy is the *total* kinetic energy of particles of matter. Does this mean that matter with a lower temperature has less thermal energy than matter with a higher temperature? Not necessarily. Another factor also affects thermal energy. The other factor is mass.

Q: Look at the pot of soup and the tub of water in the **Figure** 5.1. Which do you think has greater thermal energy?

A: The soup is boiling hot and has a temperature of 100 °C, whereas the water in the tub is just comfortably warm, with a temperature of about 38 °C. Although the water in the tub has a much lower temperature, it has greater thermal energy.

FIGURE 5.1

The particles of soup have greater average kinetic energy than the particles of water in the tub, explaining why the soup has a higher temperature. However, the mass of the water in the tub is much greater than the mass of the soup in the pot. This means that there are many more particles of water than soup. All those moving particles give the water in the tub greater total kinetic energy, even though their average kinetic energy is less. Therefore, the water in the tub has greater thermal energy than the soup. To compare the thermal energy of some other materials, go to the following URL and click on the interactive animation "Temperature and Thermal Energy."

http://www.absorblearning.com/media/item.action?quick=ad

Q: Could a block of ice have more thermal energy than a pot of boiling water?

A: Yes, the block of ice could have more thermal energy if its mass was much greater than the mass of the boiling water.

Summary

- The total kinetic energy of moving particles of matter is called thermal energy.
- The thermal energy of matter depends on how fast its particles are moving on average, which is measured by temperature, and also on how many particles there are, which is measured by mass.

Vocabulary

- **temperature**: Average kinetic energy of particles of matter.
- **thermal energy**: Total kinetic energy of all the atoms that make up an object.

Practice

Review thermal energy at the following URL, and then take the quiz at the end of the activity. http://www.bbc.co.uk/schools/ks3bitesize/science/energy_electricity_forces/energy_transfer_storage/activity.shtml

Review

1. Compare and contrast thermal energy and temperature.
2. Explain how an object with a higher temperature can have less thermal energy than an object with a lower temperature.

References

1. Warren Price Photography, Losevsky Photo and Video. . Used under license from Shutterstock.com

Chapter 6 Heat Conduction

- Define conduction and explain how it occurs.
- Describe examples of conduction.

Yummy! These cookies look delicious. But watch out! They just finished baking in a hot oven, so the cookie sheet is too hot to handle without an oven mitt. Touching the cookie sheet with bare hands could cause a painful burn. Do you know why? The answer is conduction.

What Is Conduction?

Conduction is the transfer of thermal energy between particles of matter that are touching. Thermal energy is the total kinetic energy of moving particles of matter, and the transfer of thermal energy is called heat. Conduction is one of three ways that thermal energy can be transferred (the other ways are convection and thermal radiation). Thermal energy is always transferred from matter with a higher temperature to matter with a lower temperature.

Pass It On

To understand how conduction works, you need to think about the tiny particles that make up matter. The particles of all matter are in constant random motion, but the particles of warmer matter have more energy and move more quickly than the particles of cooler matter. When particles of warmer matter collide with particles of cooler matter, they transfer some of their thermal energy to the cooler particles. From particle to particle, like dominoes falling, thermal energy moves through matter. Click on the animation "Conduction" at this URL to see an animation of conduction:

http://www.hk-phy.org/contextual/heat/hea/condu/conduction_e.html

In the opening photo above, conduction occurs between particles of metal in the cookie sheet and anything cooler that comes into contact with it—hopefully, not someone's bare hands! For a deeper understanding of this method of heat transfer, watch the animation "Conduction" at this URL:

http://www.sciencehelpdesk.com/unit/science2/3

Examples of Conduction

The cookie sheet above transfers thermal energy to the cookies and helps them bake. There are many other common examples of conduction. The **Figure** 6.1 shows a few situations in which thermal energy is transferred in this way.

FIGURE 6.1

Q: How is thermal energy transferred in each of the situations pictured above?

A: Thermal energy is transferred by conduction from the hot iron to the shirt, from the hot cup to the hand holding it, from the flame of the camp stove to the bottom of the pot as well as from the bottom of the pot to the food inside, and from the feet to the snow. The shirt, hand, pot, food, and snow become warmer because of the transferred energy. Because the feet lose thermal energy, they feel colder.

Summary

- Conduction is the transfer of thermal energy between particles of matter that are touching. Thermal energy is always transferred from particles of warmer matter to particles of cooler matter.
- When particles of warmer matter collide with particles of cooler matter, they transfer some of their thermal energy to the cooler particles.

Vocabulary

- **conduction**: Transfer of thermal energy between particles of matter that are touching.

Practice

Watch the video about conduction at the following URL. Then write a paragraph explaining how conduction is related to state of matter.

http://wn.com/heat_conduction?orderby=relevance&upload_time=this_month

Review

1. What is conduction?
2. How does conduction occur?
3. Describe an original example of conduction.

References

1. Stephen Coburn, dragon_fang, LianeM, Ma Spitz. .

CHAPTER 7 Thermal Conductors and Insulators

- Define and give examples of thermal conductors.
- Describe thermal insulators and ways they are used.

Do you like toast? Did you ever look inside a toaster while it's toasting bread? When you push down the lever to turn on the toaster, the metal heating element inside starts to glow orange or red almost instantly. You can see the glowing heating element inside this yellow toaster. The glowing metal shows that the heating element has become very hot. It gets hot so quickly because metals are good conductors of thermal energy.

Thermal Conductors

Conduction is the transfer of thermal energy between particles of matter that are touching. Thermal conduction occurs when particles of warmer matter bump into particles of cooler matter and transfer some of their thermal energy to the cooler particles. Conduction is usually faster in certain solids and liquids than in gases. Materials that are good conductors of thermal energy are called **thermal conductors**. Metals are especially good thermal conductors because they have freely moving electrons that can transfer thermal energy quickly and easily.

Besides the heating element inside a toaster, another example of a thermal conductor is a metal radiator, like the one in the **Figure** 7.1. When hot water flows through the coils of the radiator, the metal quickly heats up by conduction and then radiates thermal energy into the surrounding air.

FIGURE 7.1

Q: Thermal conductors have many uses, but sometimes it's important to prevent the transfer of thermal energy. Can you think of an example?

A: One example is staying warm on a cold day. You will stay warmer if you can prevent the transfer of your own thermal energy to the outside air.

Thermal Insulators

One way to retain your own thermal energy on a cold day is to wear clothes that trap air. That's because air, like other gases, is a poor conductor of thermal energy. The particles of gases are relatively far apart, so they don't bump into each other or into other things as often as the more closely spaced particles of liquids or solids. Therefore, particles of gases have fewer opportunities to transfer thermal energy. Materials that are poor thermal conductors are called **thermal insulators**. Down-filled snowsuits, like those in the **Figure** 7.2, are good thermal insulators because their feather filling traps a lot of air.

Another example of a thermal insulator is pictured in the **Figure** 7.3. The picture shows fluffy pink insulation inside the wall of a home. Like the down filling in a snowsuit, the insulation traps a lot of air. The insulation helps to prevent the transfer of thermal energy into the house on hot days and out of the house on cold days. Other materials that are thermal insulators include plastic and wood. That's why pot handles and cooking utensils are often made of these materials. Notice that the outside of the toaster pictured above is made of plastic. The plastic casing helps prevent the transfer of thermal energy from the heating element inside to the outer surface of the toaster where it could cause burns. You can learn more about thermal insulators at this URL: http://www.school-for-champions.com/science/thermal_insulation.htm

Q: Thermal insulators have many practical uses besides the uses mentioned above. Can you think of others?

FIGURE 7.2

FIGURE 7.3

A: Thermal insulators are often used to keep food or drinks hot or cold. For example, Styrofoam® coolers and thermos containers are used for these purposes.

With the interactive activity at the following URL, you can test different materials to see how well they prevent the transfer of thermal energy. http://www.bbc.co.uk/schools/scienceclips/ages/8_9/keeping_warm_fs.shtml

Summary

- Materials that are good conductors of thermal energy are called thermal conductors. Metals are very good thermal conductors.
- Materials that are poor conductors of thermal energy are called thermal insulators. Gases such as air and materials such as plastic and wood are thermal insulators.

Vocabulary

- **thermal conductor**: Material that is a good conductor of thermal energy.
- **thermal insulator**: Material that is a poor conductor of thermal energy.

Practice

Complete the worksheet at the following URL. http://www.bp.com/liveassets/bp_internet/bpes_new/bpes_new_uk/STAGING/protected_assets/flash/ysi_full/downloads/KeepingCosy_Worksheet1.pdf

Review

1. What is a thermal conductor? Give an example.
2. Why do metals often feel cool to the touch?
3. Define thermal insulator. Describe one way thermal insulators are used.

References

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3. . . used under license shutterstock.com

CHAPTER 8 Mechanical Wave

- Describe mechanical waves.
- Define the medium of a mechanical wave.
- Identify three types of mechanical waves.

No doubt you've seen this happen. Droplets of water fall into a body of water, and concentric circles spread out through the water around the droplets. The concentric circles are waves moving through the water.

Waves in Matter

The waves in the picture above are examples of mechanical waves. A **mechanical wave** is a disturbance in matter that transfers energy through the matter. A mechanical wave starts when matter is disturbed. A source of energy is needed to disturb matter and start a mechanical wave.

Q: Where does the energy come from in the water wave pictured above?

A: The energy comes from the falling droplets of water, which have kinetic energy because of their motion.

The Medium

The energy of a mechanical wave can travel only through matter. The matter through which the wave travels is called the **medium** (*plural*, media). The medium in the water wave pictured above is water, a liquid. But the medium of a mechanical wave can be any state of matter, even a solid.

Q: How do the particles of the medium move when a wave passes through them?

A: The particles of the medium just vibrate in place. As they vibrate, they pass the energy of the disturbance to the particles next to them, which pass the energy to the particles next to them, and so on. Particles of the medium don't actually travel along with the wave. Only the energy of the wave travels through the medium.

Types of Mechanical Waves

There are three types of mechanical waves: transverse, longitudinal, and surface waves. They differ in how particles of the medium move. You can see this in the **Figure** 10.3 and in the animation at the following URL. http://www.acs.psu.edu/drussell/Demos/waves/wavemotion.html

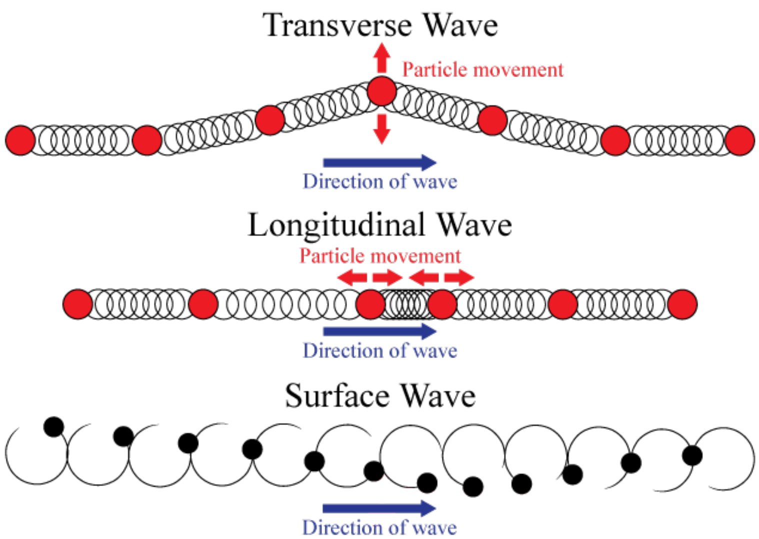


FIGURE 8.1

- In a transverse wave, particles of the medium vibrate up and down perpendicular to the direction of the wave.
- In a longitudinal wave, particles of the medium vibrate back and forth parallel to the direction of the wave.
- In a surface wave, particles of the medium vibrate both up and down and back and forth, so they end up moving in a circle.

Q: How do you think surface waves are related to transverse and longitudinal waves?

A: A surface wave is combination of a transverse wave and a longitudinal wave.

Summary

- A mechanical wave is a disturbance in matter that transfers energy through the matter.
- The matter through which a mechanical wave travels is called the medium (*plural*, media).
- There are three types of mechanical waves: transverse, longitudinal, and surface waves. They differ in how particles of the medium move when the energy of the wave passes through.

Vocabulary

- **mechanical wave**: Disturbance in matter that transfers energy from one place to another.
- **medium** (plural, **media**): Matter through which a mechanical wave moves.

Practice

At the following URL, read the short introduction to waves and watch the animations. Then answer the questions below. http://www.acs.psu.edu/drussell/Demos/waves-intro/waves-intro.html

1. The article gives a dictionary definition of wave. What is the most important part of this definition?
2. What happens to particles of the medium when a wave passes?
3. How is “doing the wave” in a football stadium like a mechanical wave?

Review

1. Define mechanical wave.
2. What is the medium of a mechanical wave?
3. List three types of mechanical waves.
4. If you shake one end of a rope up and down, a wave passes through the rope. Which type of wave is it?

References

1. CK-12 Foundation. . CC-BY-NC-SA 3.0

CHAPTER 9 Wave Amplitude

- Define wave amplitude.
- State how to measure the amplitude of transverse and longitudinal waves.
- Explain what determines the amplitude of a wave.

On a windy day, moving air particles strike these flags and transfer their energy of motion to particles of fabric. The energy travels through the fabric in waves. You can see the waves rippling through the brightly colored cloth. The windier the day is, the more vigorously the flags wave.

What's the Matter?

Waves that travel through matter—such as the fabric of a flag—are called mechanical waves. The matter they travel through is called the medium. When the energy of a wave passes through the medium, particles of the medium move. The more energy the wave has, the farther the particles of the medium move. The distance the particles move is measured by the wave's amplitude.

What Is Wave Amplitude?

Wave amplitude is the maximum distance the particles of the medium move from their resting positions when a wave passes through. The resting position of a particle of the medium is where the particle would be in the absence of a wave. The **Figure** 10.3 show the amplitudes of two different types of waves: transverse and longitudinal waves.

- In a transverse wave, particles of the medium move up and down at right angles to the direction of the wave. Wave amplitude of a transverse wave is the difference in height between the crest and the resting position. The crest is the highest point particles of the medium reach. The higher the crests are, the greater the amplitude of the wave.
- In a longitudinal wave, particles of the medium move back and forth in the same direction as the wave. Wave amplitude of a longitudinal wave is the distance between particles of the medium where it is compressed by the wave. The closer together the particles are, the greater the amplitude of the wave.

You can simulate waves with different amplitudes in the animation at this URL: http://sci-culture.com/advancedpoll/GCSE/sine%20wave%20simulator.html

Q: What do you think determines a wave's amplitude?

A: Wave amplitude is determined by the energy of the disturbance that causes the wave.

Energy and Amplitude

A wave caused by a disturbance with more energy has greater amplitude. Imagine dropping a small pebble into a pond of still water. Tiny ripples will move out from the disturbance in concentric circles. The ripples are low-amplitude waves with very little energy. Now imagine throwing a big boulder into the pond. Very large waves will be generated by the disturbance. These waves are high-amplitude waves and have a great deal of energy.

Summary

- Wave amplitude is the maximum distance the particles of the medium move from their resting positions when a wave passes through.
- Wave amplitude of a transverse wave is the difference in height between a crest and the resting position. Wave amplitude of a longitudinal wave is the distance between particles of the medium where it is compressed by the wave.
- Wave amplitude is determined by the energy of the disturbance that causes the wave. A wave caused by a disturbance with more energy has greater amplitude.

Vocabulary

- **wave amplitude**: Maximum distance the particles of a medium move from their resting positions when a wave passes through.

Practice

Read about wave amplitude at the following URL. Examine the graphs and answer the two questions. Click on the links to see if your answers are correct. http://cse.ssl.berkeley.edu/light/measure_amp.html#measure4

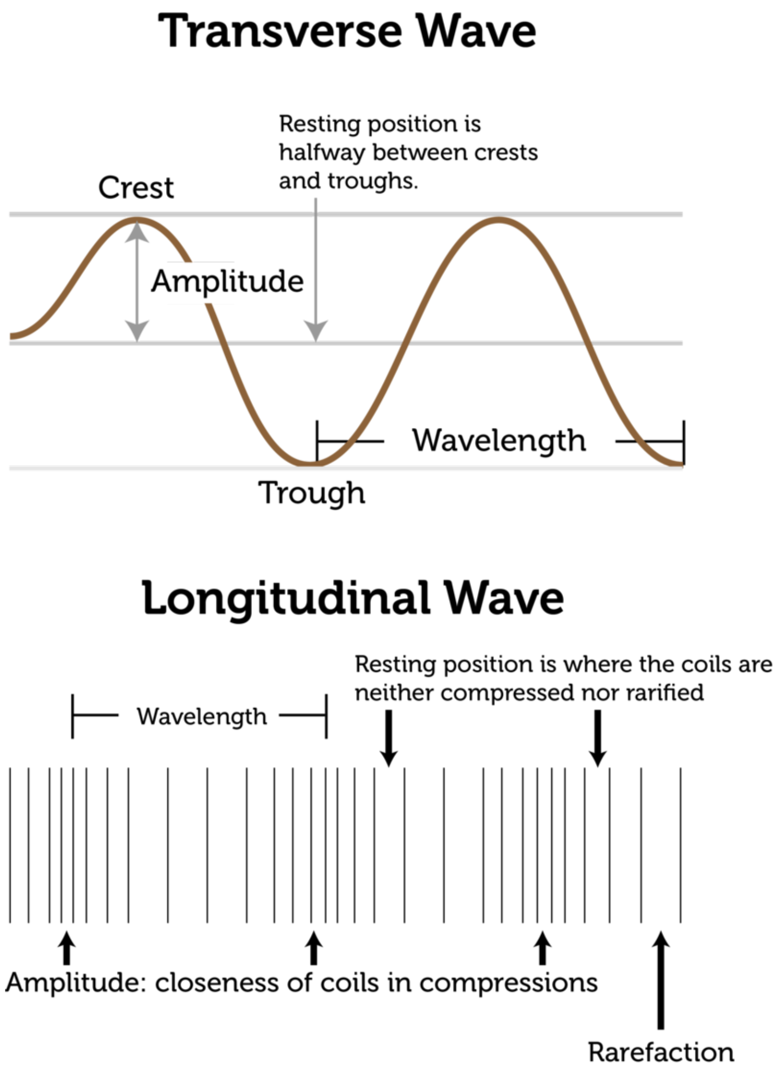


FIGURE 9.1

Review

1. Define wave amplitude.
2. What is the amplitude of the transverse wave modeled in the **Figure** 9.2 if the height of a crest is 3 cm above the resting position of the medium?
3. Which of these two longitudinal waves has greater amplitude? (See **Figure** 9.3)
4. Relate wave amplitude to wave energy.

References

1. Christopher Auyeung. . CC-BY-NC-SA
2. CK-12 Foundation. . CC-BY-NC-SA 3.0
3. CK-12 Foundation. . CC-BY-NC-SA 3.0

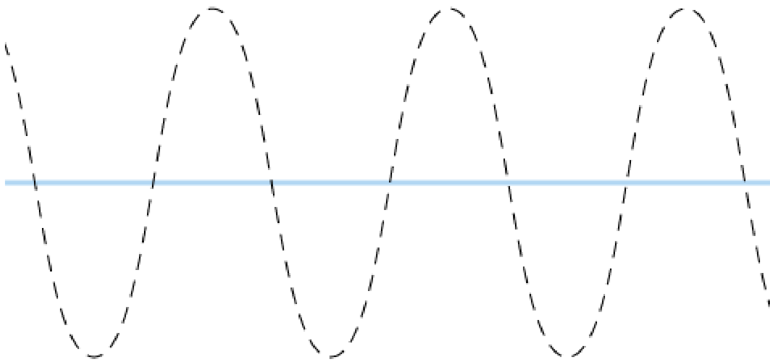


FIGURE 9.2

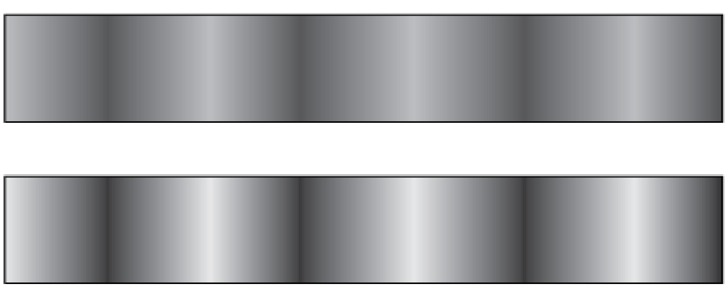


FIGURE 9.3

CHAPTER 10 Wavelength

- Define wavelength.
- Describe the wavelength of transverse and longitudinal waves.
- Relate wavelength to the energy of a wave.

Nobody really has such colorful eyes! The colors were added digitally after the photo was taken. They represent all the different colors of light. Light is a form of energy that travels in waves. Light of different colors has different wavelengths.

Defining Wavelength

Wavelength is one way of measuring the size of waves. It is the distance between two corresponding points on adjacent waves, and it is usually measured in meters. How it is measured is a little different for transverse and longitudinal waves.

- In a transverse wave, particles of the medium vibrate up and down at right angles to the direction that the wave travels. The wavelength of a transverse wave can be measured as the distance between two adjacent crests, or high points, as shown in the diagram below.

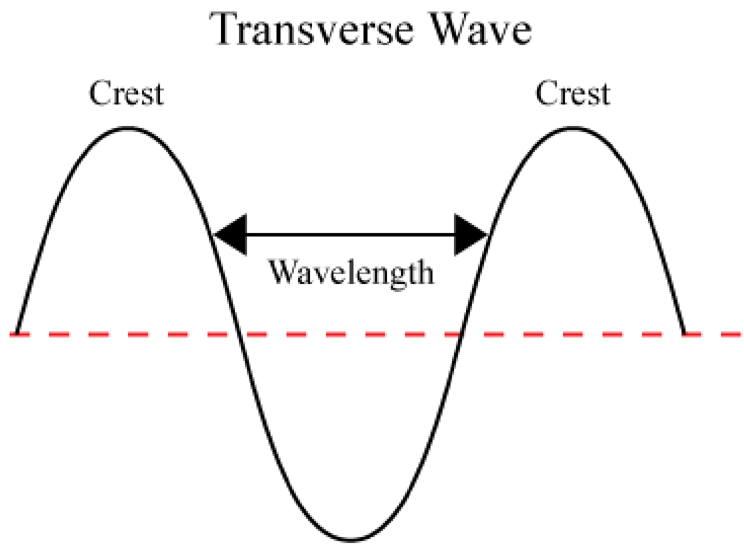


FIGURE 10.1

- In a longitudinal wave, particles of matter vibrate back and forth in the same direction that the wave travels. The wavelength of a longitudinal wave can be measured as the distance between two adjacent compressions, as shown in the diagram below. Compressions are the places where particles of the medium crowd close together as the energy of the wave passes through.

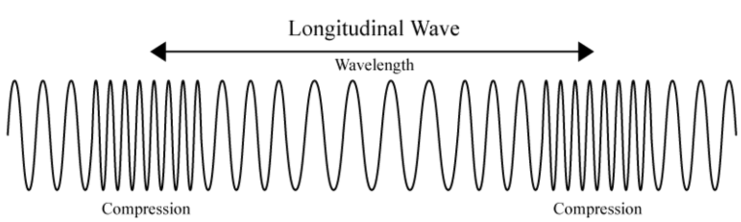


FIGURE 10.2

At the following URL, watch the animation to see examples of wavelength. Also, get a feel for wavelength by playing with the wave generator. http://earthguide.ucsd.edu/wav/wavelength.html

Wavelength and Wave Energy

The wavelength of a wave is related to the wave's energy. Short-wavelength waves have more energy than long-wavelength waves of the same amplitude. (Amplitude is a measure of how far particles of the medium move up and down or back and forth when a wave passes through them.) You can see examples of transverse waves with shorter and longer wavelengths in the **Figure** 10.3.

Q: Of all the colors of visible light, red light has the longest wavelength and violet light has the shortest wavelength. Which color of light has the greatest energy?

A: Violet light has the greatest energy because it has the shortest wavelength.

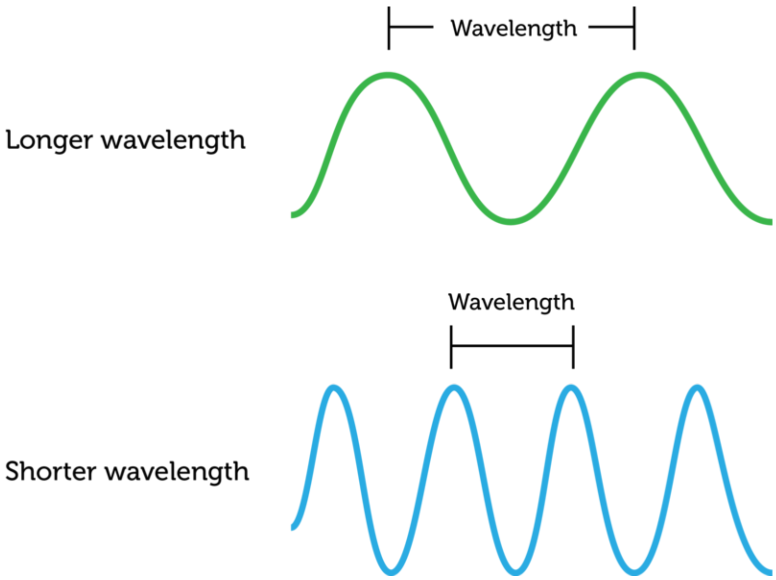


FIGURE 10.3

Summary

- Wavelength is one way of measuring the size of waves. It is the distance between two corresponding points on adjacent waves, usually measured in meters.
- The wavelength of a transverse wave can be measured as the distance between two adjacent crests. The wavelength of a longitudinal wave can be measured as the distance between two adjacent compressions.
- Short-wavelength waves have more energy than long-wavelength waves of the same amplitude.

Vocabulary

- **wavelength**: Distance between two corresponding points of adjacent waves, such as the distance between two adjacent crests of a transverse wave.

Practice

At the following URL, read about the anatomy of a wave. Then do the Check Your Understanding questions at the bottom of the Web page. Be sure to check your answers. http://www.physicsclassroom.com/class/waves/u10l2a.cfm

Review

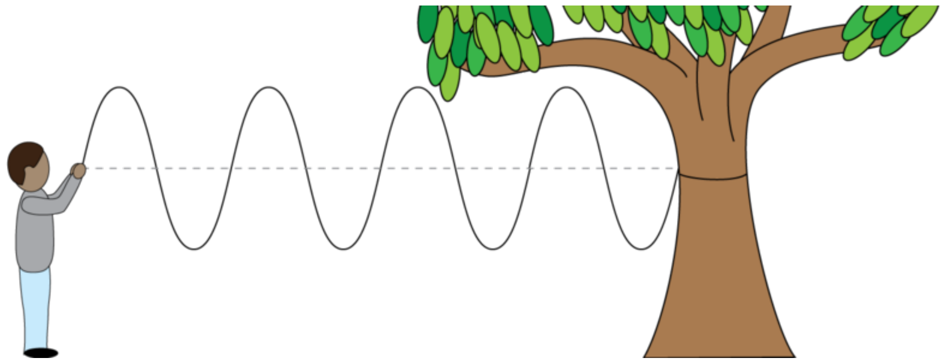
1. What is the wavelength of a wave?
2. Draw a simple transverse wave and label the wavelength.

References

1. CK-12 Foundation. . CC-BY-NC-SA 3.0
2. CK-12 Foundation. . CC-BY-NC-SA 3.0
3. Christopher Auyeung. . CC-BY-NC-SA

CHAPTER 11 Wave Frequency

- Define wave frequency.
- Identify the SI unit for wave frequency.
- Explain how wave frequency is related to the energy of a wave.



Imagine making transverse waves in a rope, like the person in the sketch above. You tie one end of the rope to a tree or other fixed point, and then you shake the other end of the rope up and down with your hand. You can move the rope up and down slowly or quickly. How quickly you move the rope determines the frequency of the waves.

What Is Wave Frequency?

The number of waves that pass a fixed point in a given amount of time is **wave frequency**. Wave frequency can be measured by counting the number of crests (high points) of waves that pass the fixed point in 1 second or some other time period. The higher the number is, the greater the frequency of the waves. The SI unit for wave frequency is the **hertz (Hz)**, where 1 hertz equals 1 wave passing a fixed point in 1 second. The **Figure** 11.1 shows high-frequency and low-frequency transverse waves. You can simulate transverse waves with different frequencies at these URLs:http://phet.colorado.edu/en/simulation/wave-on-a-string and http://zonalandeducation.com/mstm/physics/waves/partsOfAWave/waveParts.htm

Q: The wavelength of a wave is the distance between corresponding points on adjacent waves. For example, it is the distance between two adjacent crests in the transverse waves in the diagram. Infer how wave frequency is related to wavelength.

A: Waves with a higher frequency have crests that are closer together, so higher frequency waves have shorter wavelengths.

Wave Frequency and Energy

The frequency of a wave is the same as the frequency of the vibrations that caused the wave. For example, to generate a higher-frequency wave in a rope, you must move the rope up and down more quickly. This takes more energy, so a higher-frequency wave has more energy than a lower-frequency wave with the same amplitude. You can see examples of different frequencies in the **Figure** 11.2 (Amplitude is the distance that particles of the medium move when the energy of a wave passes through them.)

Summary

- Wave frequency is the number of waves that pass a fixed point in a given amount of time.

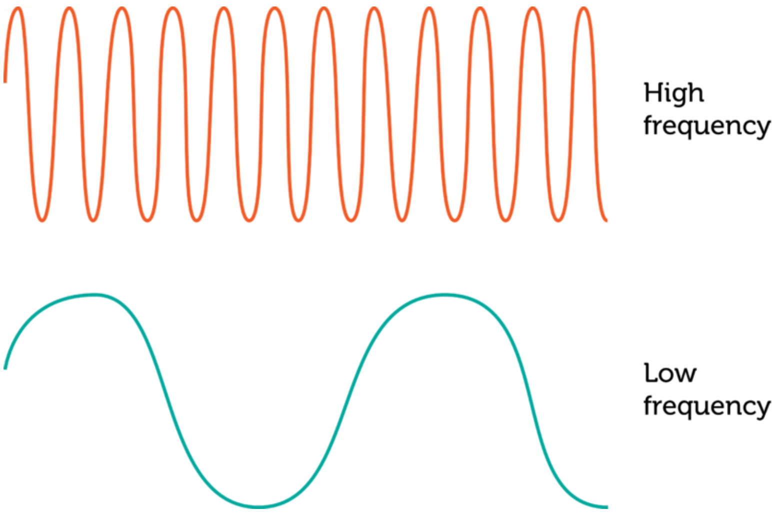


FIGURE 11.1

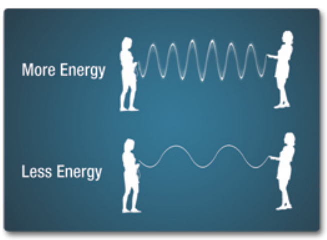


FIGURE 11.2

- The SI unit for wave frequency is the hertz (Hz), where 1 hertz equals 1 wave passing a fixed point in 1 second.
- A higher-frequency wave has more energy than a lower-frequency wave with the same amplitude.

Vocabulary

- **hertz (Hz)**: SI unit of wave frequency, where 1 hertz equals 1 wave passing a fixed point per second.
- **wave frequency**: Number of waves that pass a fixed point in a given amount of time.

Practice

At the following URL, use the wave simulator to make waves with various amounts of energy. Measure the frequency and wavelength of the waves, and check your measurements. Then answer the question at the bottom of the Web page. http://amazing-space.stsci.edu/resources/explorations/light/makewaves-frames.html

Review

1. What is wave frequency?
2. What is the SI unit for wave frequency?
3. Assume that 10 waves pass a fixed point in 5 seconds. What is the frequency of the waves in hertz?
4. Relate wave frequency to the energy of waves.

References

1. Christopher Auyeung. . CC-BY-NC-SA
2. . . used under license from Shutterstock

CHAPTER 12 Wave Interactions

- Identify ways that waves can interact with matter.
- Define and give examples of wave reflection, refraction, and diffraction.

Did you ever hear an echo of your own voice? An echo occurs when sound waves bounce back from a surface that they can't pass through. The girl pictured here is trying to create an echo by shouting toward a large building. When the sound waves strike the wall of the building, most of them bounce back toward the girl, and she hears an echo of her voice. An echo is just one example of how waves interact with matter.

How Waves Interact with Matter

Waves interact with matter in several ways. The interactions occur when waves pass from one medium to another. The types of interactions are reflection, refraction, and diffraction. Each type of interaction is described in detail below. You can see animations of the three types at this URL: http://www.acoustics.salford.ac.uk/schools/teacher/lesson3/flash/whiteboardcomplete.swf

Reflection

An echo is an example of wave reflection. **Reflection** occurs when waves bounce back from a surface they cannot pass through. Reflection can happen with any type of waves, not just sound waves. For example, light waves can also be reflected. In fact, that's how we see most objects. Light from a light source, such as the sun or a light bulb, shines on the object and some of the light is reflected. When the reflected light enters our eyes, we can see the object.

Reflected waves have the same speed and frequency as the original waves before they were reflected. However, the direction of the reflected waves is different. When waves strike an obstacle head on, the reflected waves bounce straight back in the direction they came from. When waves strike an obstacle at any other angle, they bounce back at the same angle but in a different direction. This is illustrated in diagram below. In this diagram, waves strike a wall at an angle, called the angle of incidence. The waves are reflected at the same angle, called the angle of reflection, but in a different direction. Notice that both angles are measured relative to a line that is perpendicular to the wall.

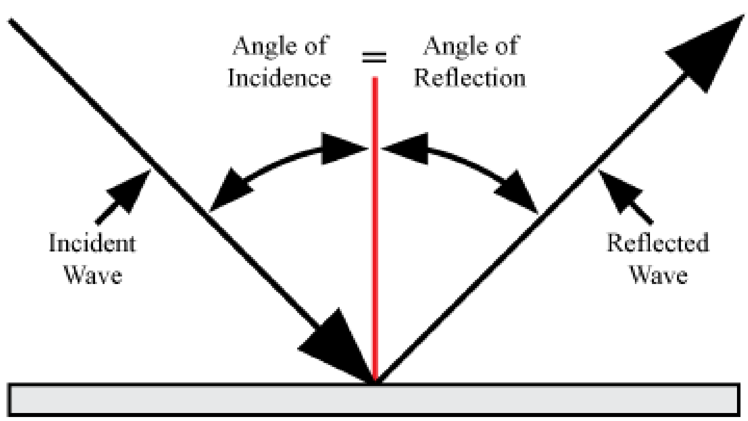


FIGURE 12.1

Refraction

Refraction is another way that waves interact with matter. **Refraction** occurs when waves bend as they enter a new medium at an angle. You can see an example of refraction in the picture below. Light bends when it passes from air to water or from water to air. The bending of the light traveling from the fish to the man's eyes causes the fish to appear to be in a different place from where it actually is.

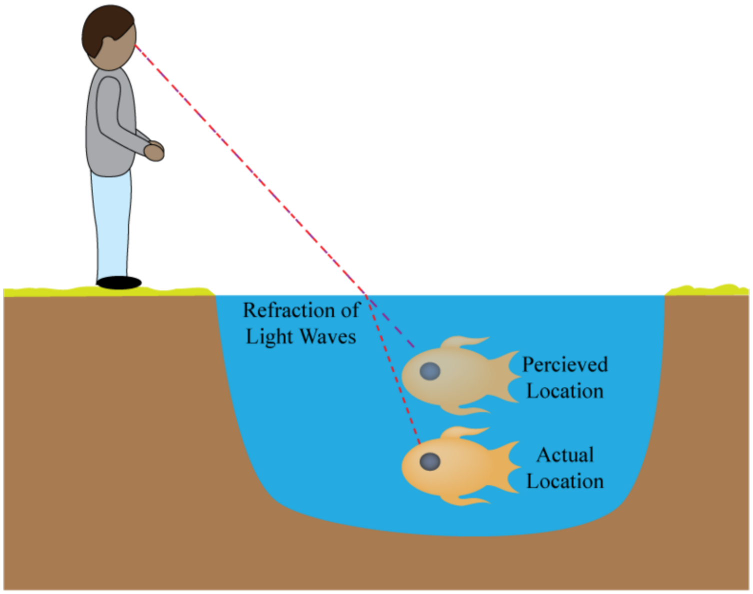


FIGURE 12.2

Waves bend as they enter a new medium because they start traveling at a different speed in the new medium. For example, light travels more slowly in water than in air. This causes it to refract when it passes from air to water or from water to air.

Q: Where would the fish appear to be if the man looked down at it from straight above its actual location?

A: The fish would appear to be where it actually is because refraction occurs only when waves (in this case light waves from the fish) enter a new medium at an angle other than 90 °.

Diffraction

Did you ever notice that you can hear sounds around the corners of buildings even though you can't see around them? The **Figure** 12.3 shows why this happens. As you can see from the figure, sound waves spread out and travel around obstacles. This is called **diffraction**. It also occurs when waves pass through an opening in an obstacle. All waves may be diffracted, but it is more pronounced in some types of waves than others. For example, sound waves bend around corners much more than light does. That's why you can hear but not see around corners.

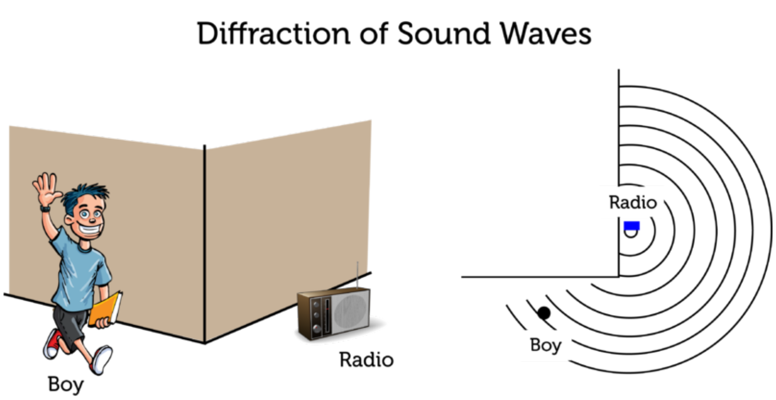


FIGURE 12.3

For a given type of waves, such as sound waves, how much the waves diffract depends on the size of the obstacle (or opening in the obstacle) and the wavelength of the waves. The **Figure** 12.4 shows how the amount of diffraction is affected by the size of the opening in a barrier. Note that the wavelength of the wave is the distance between the vertical lines.

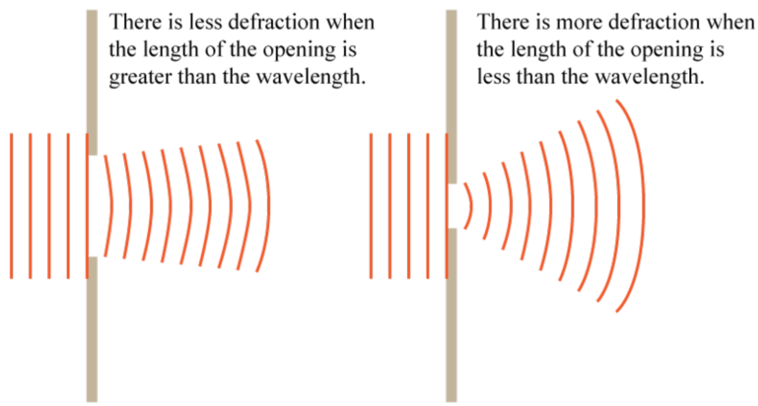


FIGURE 12.4

Summary

- Three ways that waves may interact with matter are reflection, refraction, and diffraction.
- Reflection occurs when waves bounce back from a surface that they cannot pass through.
- Refraction occurs when waves bend as they enter a new medium at an angle and start traveling at a different speed.
- Diffraction occurs when waves spread out as they travel around obstacles or through openings in obstacles.

Vocabulary

- **diffraction**: Bending of a wave around an obstacle or through an opening in an obstacle.
- **reflection**: Bouncing back of waves from a barrier they cannot pass through.
- **refraction**: Bending of waves as they enter a new medium at an angle and change speed.

Practice

Make a crossword puzzle of terms relating to wave interactions. Include at least seven different terms. You can use the puzzle maker at the following URL. Then exchange and solve puzzles with a classmate. http://puzzlemaker.discoveryeducation.com/CrissCrossSetupForm.asp

Review

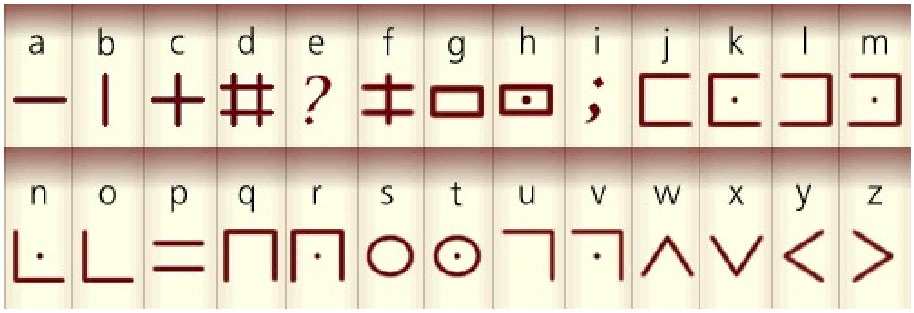
1. What is reflection? What happens if waves strike a reflective surface at an angle other than 90 °?
2. Define refraction. Why does refraction occur?
3. When does diffraction occur? How is wavelength related to diffraction?

References

1. CK-12 Foundation. . CC-BY-NC-SA 3.0
2. CK-12 Foundation. . CC-BY-NC-SA 3.0
3. . . used under license from Shutterstock.com
4. CK-12 Foundation. . CC-BY-NC-SA 3.0

CHAPTER 13 Electronic Signal

- Define electronic signal and electronics.
- Compare and contrast analog and digital signals.



Did you ever make a secret code by assigning each letter of the alphabet a unique symbol? The code shown above is believed to have been used by George Washington to send secret messages during the American Revolutionary War. A different type of code can be sent with electric current.

Q: How do you think electric current can be used to encode messages?

A: The short answer is by changing the voltage in an electric circuit. Keep reading to learn more.

Electronic Messages

Electric devices, such as lights and household appliances, change electric current to other forms of energy. For example, an electric stove changes electric current to thermal energy. Other common devices, such as mobile phones and computers, use electric current for another purpose: to encode information. A message encoded this way is called an **electronic signal**, and the use of electric current for this purpose is called **electronics**. For an overview of electronics and electronic signals, read the short article at this URL: http://www.bbc.co.uk/scotland/learning/bitesize/standard/physics/electronics/overview_rev1.shtml

To encode a message with electric current, the voltage is changed rapidly, over and over again. Voltage is a difference in electric potential energy that is needed in order for electric current to flow. There are two different ways voltage can be changed, resulting in two different types of electronic signals, called analog signals and digital signals.

Analog Signals

Analog signals consist of continuously changing voltage in an electric circuit. The **Figure** 13.1 represents analog signals. These were the first electronic signals to be invented. They were used in early computers and other early electronic devices. Analog signals are subject to distortion and noise, so they aren't used as often anymore. They are used mainly in microphones and some mobile phones to encode sounds as electronic signals.

Digital Signals

Today, most electronic signals are digital signals. Digital signals consist of rapid pulses of voltage that repeatedly switch the current off and on. The **Figure** 13.2 represents digital signals. This type of signal encodes information as a string of 0's (current off) and 1's (current on). This is called a binary ("two-digit") code. The majority of modern electronic devices, including computers and many mobile phones, encode data as digital signals. Compared with analog signals, digital signals are easier to transmit and more accurate.

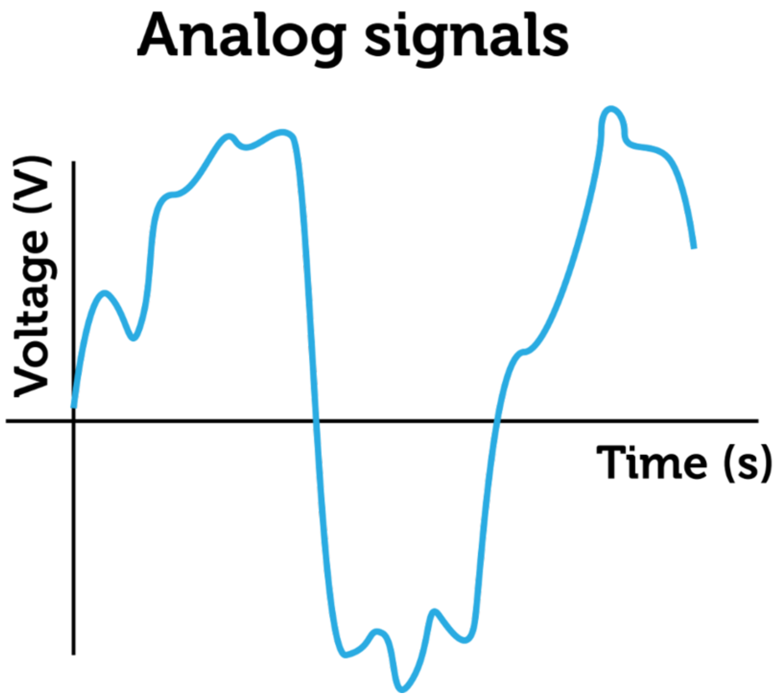


FIGURE 13.1

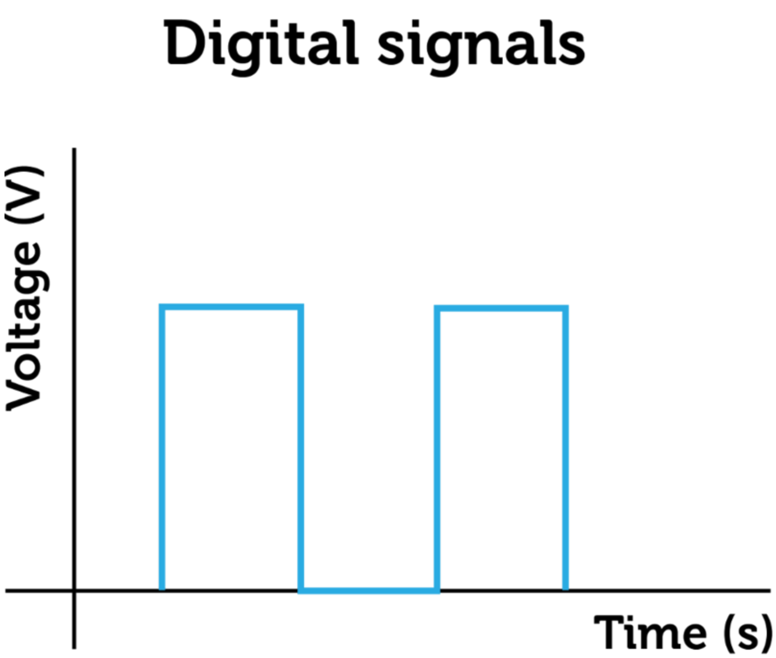


FIGURE 13.2

Summary

- A message encoded by changing the voltage of an electric current is called an electronic signal. The use of electric current for this purpose is known as electronics.
- Electronic signals may be analog or digital signals. Analog signals consist of continuously changing voltage in an electric circuit. Digital signals, which are the main type of signals used today, consist of rapid pulses of voltage that repeatedly switch the current off and on.

Vocabulary

- **electronic signal**: Use of electric current to encode information.
- **electronics**: Message encoded by changing the voltage of electric current.

Practice

Assume you are explaining analog and digital signals to a younger student. Write an original analogy that helps explain how the two types of signals differ. You can learn more about analogies, including many examples, at the following URL. http://grammar.about.com/od/topicsuggestions/a/Thirty-Writing-Topics-Analogy.htm

Review

1. What is an electronic signal?
2. Define electronics.
3. Create a table comparing and contrasting analog and digital signals.

References

1. Christopher Auyeung/CK-12 Foundation. . CC-BY-NC-SA 3.0
2. Christopher Auyeung/CK-12 Foundation. . CC-BY-NC-SA 3.0

CHAPTER 14 Light

- Identify electromagnetic waves that are commonly called light.
- Describe infrared light and its sources.
- Distinguish visible light from other wavelengths of light.
- Describe ultraviolet light, and explain why it is dangerous.

Slip! Slop! Slap! Did you ever hear this slogan? It stands for *slip* on a shirt, *slop* on some sunscreen, and *slap* on a hat. The slogan originated in Australia in the 1980s, but it has since been adopted in many other places around the globe. It sums up simple steps you can take to protect your skin from sunlight. Sunlight consists of a wide range of electromagnetic waves, some of which are harmful.

The Waves in Sunlight

Electromagnetic waves are waves that carry energy through matter or space as vibrating electric and magnetic fields. Electromagnetic waves have a wide range of wavelengths and frequencies. Sunlight contains the complete range of wavelengths of electromagnetic waves, which is called the electromagnetic spectrum. The **Figure** 14.1 shows all the waves in the spectrum.

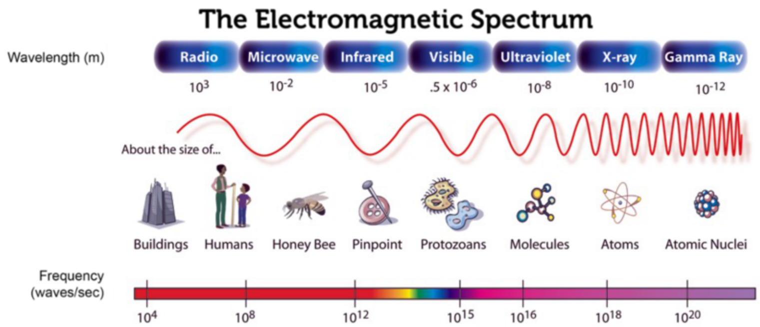


FIGURE 14.1

Let There Be Light

Light includes infrared light, visible light, and ultraviolet light. As you can see from the diagram above, light falls roughly in the middle of the electromagnetic spectrum. It has shorter wavelengths and higher frequencies than microwaves, but not as short and high as X rays.

Q: Which type of light do you think is harmful to the skin?

A: Waves of light with the highest frequencies have the most energy and are harmful to the skin. Use the electromagnetic spectrum above to find out which of the three types of light have the highest frequencies.

Infrared Light

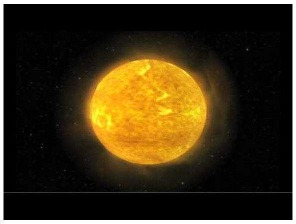
Light with the longest wavelengths is called **infrared light**. The term *infrared* means "below red." Infrared light is the range of light waves that have longer wavelengths and lower frequencies than red light in the visible range of light waves. The sun gives off infrared light as do flames and living things. You can't see infrared light waves, but you can feel them as heat. But infrared cameras and night vision goggles can detect infrared light waves and convert them to visible images. For a deeper understanding of infrared light, watch the video at this URL: http://www.youtube.com/watch?v=2–0q0XlQJ0

MEDIA

Click image to the left for more content.

Visible Light

The only light that people can see is called **visible light**. This light consists of a very narrow range of wavelengths that falls between infrared light and ultraviolet light (See **Figure** 14.2). Within the visible range, we see light of different wavelengths as different colors of light, from red light, which has the longest wavelength, to violet light, which has the shortest wavelength (see the spectrum below). When all of the wavelengths of visible light are combined, as they are in sunlight, visible light appears white. You can learn more about visible light at this URL: http://www.youtube.com/watch?v=PMtC34pzKGc



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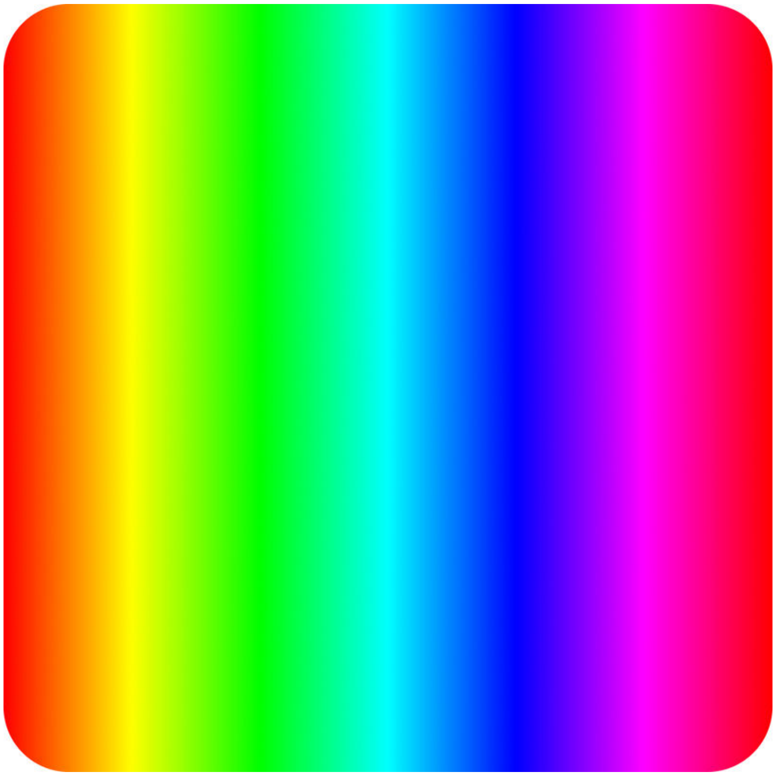
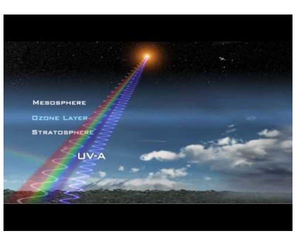


FIGURE 14.2

Ultraviolet Light

Light with wavelengths shorter than visible light is called **ultraviolet light**. The term ultraviolet means "above violet." *Ultraviolet* light is the range of light waves that have shorter wavelengths and higher frequencies than violet light in the visible range of light. With higher frequencies than visible light, ultraviolet light has more energy. It can be used to kill bacteria in food and to sterilize surgical instruments. The human skin also makes vitamin D when it is exposed to ultraviolet light. Vitamin D, in turn, is needed for strong bones and teeth. You can learn more about ultraviolet light and its discovery at this URL: http://www.youtube.com/watch?v=QW5zeVy8aE0&feature=related



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Too much exposure to ultraviolet light can cause sunburn and skin cancer. As the "slip, slop, slap" slogan suggests, you can protect your skin from ultraviolet light by wearing clothing that covers your skin, applying sunscreen to any exposed areas, and wearing a hat to protect your head from exposure. The SPF, or sun-protection factor, of sunscreen gives a rough idea of how long it protects the skin from sunburn (see **Figure** 14.3). A sunscreen with a higher SPF value protects the skin longer. Sunscreen must be applied liberally and often to be effective, and no sunscreen is completely waterproof. You can learn more about the dangers of ultraviolet light at this URL: http://www.youtube.com/watch?v=np-BBJyl-go

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FIGURE 14.3

Q: You should apply sunscreen even on cloudy days. Can you explain why?

A: Ultraviolet light can travel through clouds, so it can harm unprotected skin even on cloudy days.

Summary

- Sunlight contains the complete range of wavelengths of electromagnetic waves. The entire range is called the electromagnetic spectrum.
- Electromagnetic waves that are commonly called light fall roughly in the middle of the electromagnetic spectrum. Light includes infrared light, visible light, and ultraviolet light.
- Infrared light is light with the longest wavelengths and lowest frequencies. You can't see infrared light, but you can feel it as heat. Besides the sun, flames and living things give off infrared light.

- Visible light consists of a very narrow range of wavelengths that falls between infrared light and ultraviolet light. It is the only light that people can see. Different wavelengths of visible light appear as different colors.
- Ultraviolet light has shorter wavelengths and higher frequencies than visible light. Ultraviolet light also has more energy, which makes it useful for killing germs. Too much exposure to ultraviolet light can damage the skin.

Vocabulary

- **infrared light**: Part of the electromagnetic spectrum in which waves have a wavelength between those of radio waves and visible light.
- **ultraviolet light**: Electromagnetic radiation with a wavelength falling between the wavelengths of visible light and X rays.
- **visible light**: Range of wavelengths of electromagnetic waves that the human eye can detect.

Practice

At the first URL below, find the UV index for your zip code. Then, at the second URL, learn what this value of the index means and what steps you should take to protect yourself from this level of UV radiation. http://www.epa.gov/sunwise/uvindex.html http://www.epa.gov/sunwise/kids/kids_uvindex.html

Review

1. Relate sunlight to the electromagnetic spectrum. Where do the waves that are commonly called light fall on the spectrum?
2. Define infrared light. How can infrared light be detected?
3. What is visible light? What determines the color of visible light?
4. Describe ultraviolet light. How and why should you protect your skin from ultraviolet light?

References

1. NASA. . Public Domain
2. weknow, 2012. . used under license from Shutterstock.com
3. Kraska. . used under license from Shutterstock.com