UNIT

B

Energy Transfer Technologies

What does the science of physics have to do with fighting fires?

Plenty!

In order to protect themselves from the intense heat, firefighters wear special protective clothing. The clothing uses special materials that prevent heat transfer.

At the same time, firefighters use water to increase heat transfer. When water is sprayed over flames, the liquid water quickly heats and changes to water vapour. This change in state transfers heat away from the fire.

Put a fire ladder against the side of a building and you have an inclined plane ready to get firefighters to the heart of the fire — or to help victims to safety.

Fire axes are levers. When used to break through doors, they act as an extension of the firefighter's arm.

In this unit, you will study all of these things. You will study what heat is, how it transfers from one object to another, and how to reduce or increase heat transfer. You will also study how simple machines transfer energy.

As you work on the unit, you may consider exploring related occupations — from auto mechanic to chef.

Unit Contents

unit A PROJECT

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Detergent Dilemma

Advertisers promote one brand of detergent over another. But are their claims accurate? Even if they are, how do you decide among the many options?

In this activity, you will use what you learned in the unit to design an investigation that will help you decide which detergent works the best.

Challenge

Design an investigation that will determine how well different detergents remove stains.

Safety Precautions

- Contact with laundry detergents can irritate your eyes, lungs, and stomach.

Materials

large jar

variety of materials to make stains (such as ketchup, grass, mustard, raspberry juice)

fabric

thermometer

variety of detergents

water

Design Criteria

A. Test at least three different detergents.
Note: Be sure the detergent solutions are prepared as directed on the product's packaging. You need to test the effectiveness of each product at the concentration recommended by the manufacturer.

B. Use the same washing conditions for each detergent.

C. Include the following:
- a problem statement;
- a list of apparatus, materials, and safety precautions; and
- a detailed procedure.

D. Outline the criteria you will use to determine how well each stain was cleaned.

Plan and Construct

1. With your group, determine the washing conditions for your test.
   (a) What temperature will the water be? Include instructions for reaching this temperature.
   (b) How will you agitate the laundry? For example, you might use a jar that can be shaken or stir the mixture in a larger container such as a pail.
   (c) How *much* will you agitate the laundry? Include instructions on:
   - how long the sample will be agitated,
   - whether it will be shaken or stirred, and
   - how vigorous the agitation will be.

2. Based on your decisions in Step 1, write out the problem you will investigate. For example, "Which detergent removes stains best in cold water with gentle agitation?"

3 What type of container will you use? Add this to the list of apparatus.

What type of fabric(s) will you use? You might choose a natural fabric (such as cotton) or a synthetic (such as polyester). Or, you could test a variety of fabrics. Make a decision and add the item(s) to your list of materials.

5 How many detergent samples will you test? Add these to the list of materials. Be sure to include a variety of brands and types of detergents — some that wash in cold water, some that include bleach, and so on.

What kinds of stains will you test? Add these substances to the list of materials.

7 Write out a procedure for staining the fabric. For example, will you rub in the stains or dab them on? How large will each stain be?

How long will you leave the stains on before washing?

Detergents will irritate skin, eyes, and lungs. What safety precautions will you follow? To help you decide, research the precautions on each product's web site or MSDS. Write out the safety precautions for this investigation.

1 What control will you use? For example, how will you show that it is the detergent doing the cleaning, and not just the water and agitation?

11 How will you rate each detergent's ability to remove a stain? Write out the criteria for your assessment.

- You might compare the performances. For example, brand C left more stain visible than brand B.
- You could rate each detergent's performance against a scale. For example, you might use a scale such as:

  Level 1 — no stain visible

  Level 2 — some discoloration visible on close inspection

  Level 3 — stain clearly visible

  Level 4 — no different than the stain before washing

12 Design a table for recording your observations.

13 Have your group's procedure approved by the teacher, and then carry out the investigation.

1 Clean up any spills and wash your hands thoroughly after doing the activity.

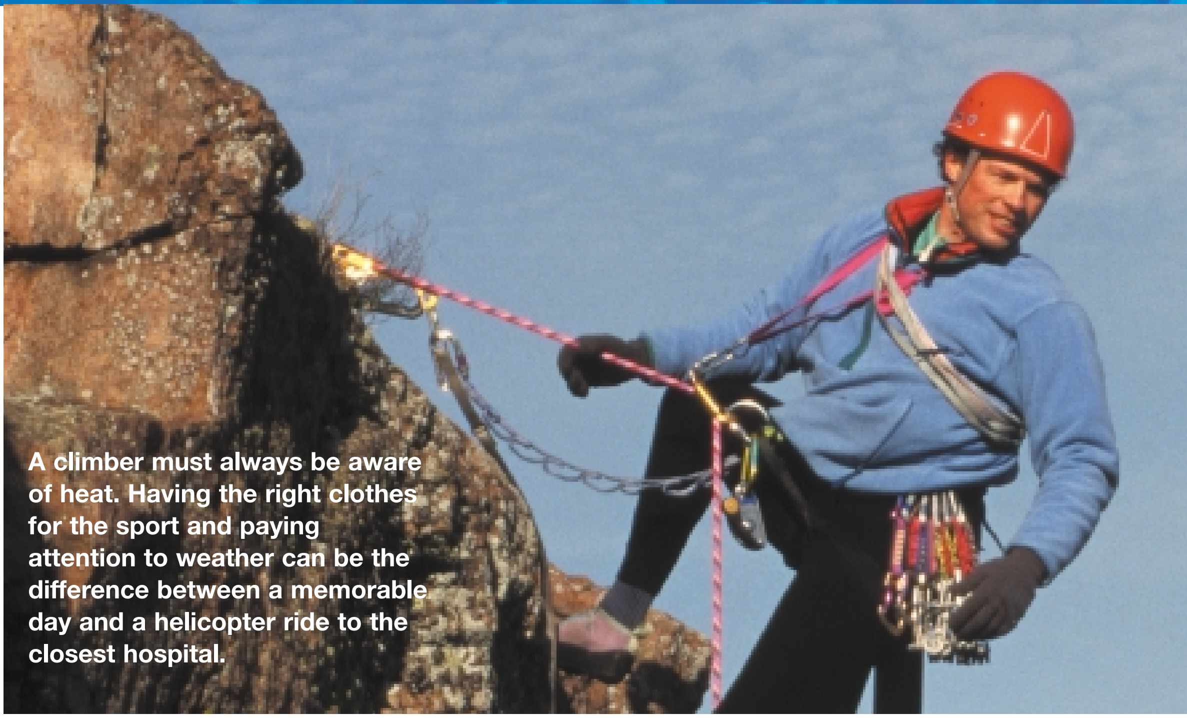
Internet CONNECT

www.mcgrawhill.ca/links/science.connect1

Manufacturers often provide safety information for their products on their web site. Go to the above web site, then to Internet Connects, Unit A, Closer, and on to Laundry Detergent Safety.

CHAPTER

5 Heat and Heat



A climber must always be aware of heat. Having the right clothes for the sport and paying attention to weather can be the difference between a memorable day and a helicopter ride to the closest hospital.

Getting Ready...

- What do car engines and human bodies have in common?
- Why does heat appear to flow?
- How does your body cool down on a hot day?

Science Log

When an object is heated, does its weight increase? Does the object get bigger? When a block of wood is warmed, has something measurable been added? Discuss this with a partner and write your ideas in your Science Log.

Climbers often depend on bare hands when climbing rocks. This one is wearing gloves because sliding down the rope can cause rope burn.

Excess heat can be a problem with weather, people, and machines. In this chapter, you will learn about the modern theory of heat. You will look at how heat travels and how heat transfer is important in various technologies. You will also study how the systems your body uses to cool down or warm up are similar to the systems used to control engine and machine temperatures.

In addition, you will study that heat can do work, how heat transfers, and how the transfer of heat affects weather. You will see how the process of heat energy transfer affects temperatures and climates on Earth.

By the end of the chapter, you will understand why knowledge of heat transfer is so important to this climber.

Transfer

In the past, many groups used bow drills to start fires.

What You Will Learn

In this chapter you will learn:

- where heat comes from
- how heat transfers from one object to another
- the way climate is controlled by heat transfer
- methods of heat transfer used by various technologies

Why It Is Important

- Your body must stay close to 37°C. If your body gets too hot, your internal organs may be harmed or you will get sick. If your body is too cold, you risk hypothermia. Is this why Canadians have more kinds of clothes than anyone else in the world?

Skills You Will Use

In this chapter you will:

- investigate processes of thermal energy transfer
- analyze technologies that transfer heat energy
- compare three methods of heat transfer
- interpret weather and climate patterns in your area

Starting Point ACTIVITY

Where Does Heat Come From?

Rappelling down a cliff face is an exhilarating experience and a fast way to get down a mountainside. Smart climbers wear gloves to protect themselves from rope burn.

How do their hands get burned? Where does the heat comes from?

Safety Precaution

What You Need

manual hand drill

drill bit

small piece of hardwood

What to Do

1. Feel the temperature of a drill bit.
2. The teacher will use the bit and drill to make a hole in a piece of hardwood.
3. Cautiously feel the bit again.
4. Wash your hands thoroughly.

What Do You Think?

1. In the above activity, where does the heat come from?
2. Look at the drawing with the bow drill. Discuss what might happen to the wood in the groove on the board.
3. Think about questions 1 and 2. Why should motorcyclists wear leather suits, even in summer?

5.1 The Nature of Heat

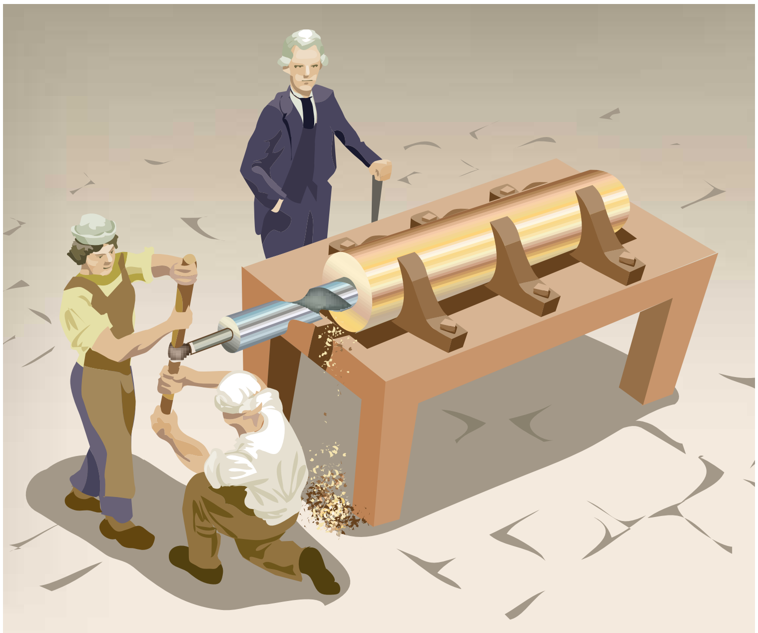


Figure 5.1 Workers boring a cannon barrel.

Friction theory has been around for centuries. When two surfaces are rubbed together, the parts that touch resist movement. This resistance is friction. It was Count Rumford who used observations about friction to change the way scientists look at heat.

In the late 1700s, Count Rumford observed that heat was created when metal cut metal. This heat results from friction. Rumford was an engineer and scientist who was hired to manufacture cannons in Munich, Germany. During this project, one worker carelessly touched a rod being used to bore a hole through a piece of metal. His hand was seriously burned.

READING Check

What did Rumford notice about heat?

Robert Brown and Random Movement

Have you ever watched popcorn popping in an air popper? The random, dancing motion of the kernels is easy to observe. The cause of this motion is easy to explain. Would it surprise you to know that a similar type of random, dancing motion is occurring in the glass of water?

Figure 5.2 Robert Brown

Internet CONNECT

www.mcgrawhill.ca/links/science.connect1

Robert Brown was a botanist studying how pollen fertilizes an egg (ovum) in a flowering plant. When observing grains of pollen under a microscope, he noticed tiny particles moving around. What was causing these particles to move? To find out, go to the above web site. Go to Internet Connects, Unit B, Chapter 5, and then to Brownian Motion.

Robert Brown was the first to realize this. During the 1800s, he was using a microscope to observe pollen grains in a drop of water. He noticed that although the microscope was quite still, the pollen grains bounced around. When he increased the temperature of the water, the jiggling motion increased.

This jiggling motion became known as **Brownian motion**.

Observing the motion was simple. Explaining the cause was much more difficult. At first, Brown thought that the pollen grains were alive. Later, he reasoned that water must be composed of tiny unseen particles. These particles are in constant, vibrating motion. The motion of the pollen grains must be caused by collisions between the pollen grains and the other unseen particles. Brown was unsure what the particles were.

Figure 5.3 In this popcorn popper, popcorn kernels are heated and kept up by a blast of hot air.

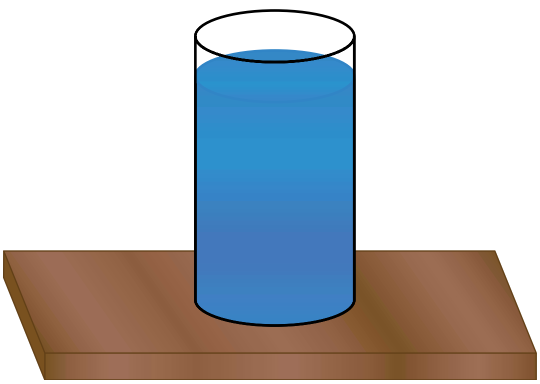


Figure 5.4 This appears to be a glass of stationary water. Brown found that the water is in constant motion.

READING Check

After reading this section and doing either the Internet Connect or Disc Connect, describe Brownian Motion and how it is affected by temperature.

Disc CONNECT

If you have ever watched a lottery draw on television, you may have observed the random motion of the numbered balls before they drop into the slot. But would you watch a glass of water with the same interest? Robert Brown, a Scottish botanist, did. While observing pollen grains under a microscope, Brown noticed that the pollen grains were moving in the water. What caused this motion? What happened to this motion when the temperature increased? To answer these and other questions, load the student CD-ROM onto your computer. Launch the **Brownian motion** applet and follow the instructions.

Figure 5.5 Robert Brown's microscope.

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Mysterious Motion

Robert Brown and the scientists who came after him had a difficult job explaining heat. The nature of heat is complex. You cannot see heat, only observe what it does. In this investigation, just like a scientist, you are going to experience things you cannot see. From your experience, you will hypothesize about what is happening.

Problem

Is water really still when is seems to be stationary?

Safety Precaution

- Be cautious with glass.
- Handle hot water carefully.

Apparatus

250 mL beaker
medicine dropper

Materials

food colouring
hot and cold water

Procedure

1 Pour 200 mL of cold tap water into the beaker.

2 Place the beaker on a table. Wait until the visible motion of the water in the beaker has stopped.

3 Draw some food colouring into the medicine dropper.

With the medicine dropper just above the surface of the water, release one drop of food colouring into the water. Do not move or disturb the beaker.

5 Observe what happens.

Repeat steps 1 to 5, this time using 200 mL of hot water.

7 Clean up any spills and wash your hands thoroughly.

Analyze

1. Describe the motion of the food colouring in each beaker of water.

2. What similarities did you observe?

3. What differences did you observe?

Conclude and Apply

4. Provide an explanation for the way the food colouring moved.

(a) What do you think caused this motion?

(b) Why didn't the drops of food colouring just remain on the surface of the water?

5. Compare the motion of the food colouring in the hot and the cold water. Explain any differences.

Extend Your Knowledge

6. Would you expect to make the same observations if you used cooking oil or vinegar instead of water? Predict what might happen. Test your prediction.

Did You Know?

The unseen particles that Brown said caused the jiggling motion interested other scientists too. These particles were first called atoms. Later, they were called molecules.

Check Your Understanding

1. What did Brown guess was the smallest part of the mixture of water and pollen grains?
2. What is the name of the motion that Brown saw with pollen grains in water? Describe this type of motion.
3. As the temperature of the water increases, what happens to the motion of food colouring in water?

Key Terms

friction
Robert Brown
Brownian motion

5.2 Heat and Temperature

Figure 5.6 Unseen particles in matter move and collide like these bumper cars.

DidYouKnow?

Heat cannot escape through a dog's thick coat. Dogs pant to get rid of excess heat.

READING Check

Two iron rods, one larger than the other, are both at the same temperature. How do their average kinetic energies compare?

The modern theory of **heat** began with Robert Brown. He was first to suggest that the energy that came with heat — or **thermal energy** — was related to the jiggling motion of unseen particles of a substance. What are these unseen particles? What causes the jiggling motion?

In Unit A, you studied the particle theory of matter, which states:

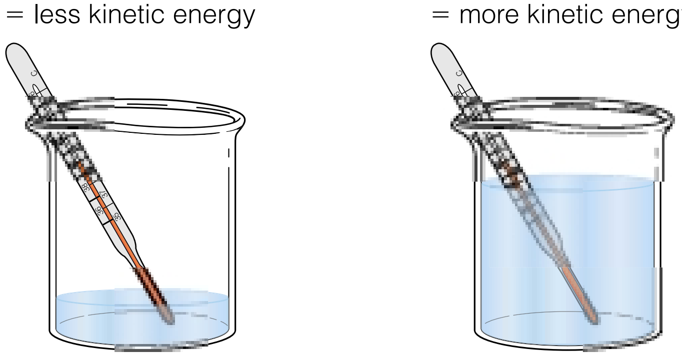
- All matter is composed of tiny, unseen particles.
- These unseen particles are in constant, random motion.

Kinetic means movement. Kinetic art, such as mobiles, is art that moves. **Kinetic energy** is a form of energy associated with motion. Kinetic energy is a measure of the amount of motion particles have. We can use kinetic energy to explain the difference between heat and temperature.

The motion of particles can be compared to bumper cars at a fair. Like bumper cars, atoms and molecules collide with each other at different speeds. All particles have different kinetic energies.

25 mL @ 30°C
= less kinetic energy

100 mL @ 30°C
= more kinetic energy



Temperature is the average of all kinetic energies of all particles in an object. The temperature of the water in both of these beakers is the same.

Heat is the sum of all kinetic energies of all particles in an object. The water in this beaker has more heat than the water in the beaker on the left.

Figure 5.7 Heat and temperature are related, but they are not the same.

Check Your Understanding

1. Explain the difference between heat and temperature.
2. You place a frying pan on a burner to fry an egg. As the pan gets hotter, how is the kinetic energy of the particles that make up the pan affected?

Key Terms

heat
thermal energy
kinetic energy
temperature

5.3 Transfer of Heat

There have been many predictions about when Earth will end. Fear of Y2K computer problems brought excitement to New Year's Eve 2000. As you study transfer of heat, you will learn about another proposed end to the universe.

Find Out ACTIVITY

Blending Water

SKILLCHECK

Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Safety Precaution

- Be careful with glass.
- Handle hot materials with care.

What You Need

3 beakers
2 thermometers
hot and cold water

What to Do

1. Pour 100 mL of water into each beaker — hot in one, cold in the other.
2. Measure the temperature of the water in each beaker.
3. Pour the water together into the empty beaker.
4. Predict what the temperature will be in two minutes. Wait, then take the temperature.
5. Wipe up any spills and wash your hands thoroughly.

What Did You Discover?

1. Was the temperature of the final mixture between the two starting temperatures?
2. Predict what the temperature will be if you did this again with 50 mL of water in each beaker.
3. Predict the final temperature for two different starting temperatures in each beaker.

SCIENCE Myths

A little more than a hundred years ago, scientists showed that light and thermal energy travel to Earth as electromagnetic waves. They knew that waves needed a substance to travel through. Scientists thought space must be made up of some type of substance. They thought that this substance was a low-density solid. They called it *aether*.

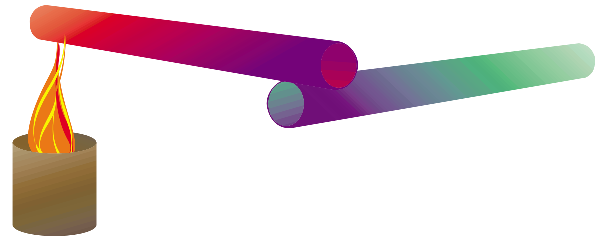


Figure 5.8 Heat flows from hot objects to cooler ones. In the Find Out Activity — Blending Water, the hot water lost heat and the cool water gained heat until the two liquids came to the same temperature. In this set-up, heat travels from the hot bar to the cool bar.

READING Check

Use a diagram to show how heat energy flows between a hot and a cold object.

Forms of Heat Transfer

Heat flows from hot to cold. The flow continues until both objects are at the same temperature. But what really happens? How does thermal energy transfer from one object to another? Read the descriptions below, and then identify each of the forms of heat transfer shown in Figure 5.9.

Conduction

In Figure 5.10, the molecules of the hot burner vibrate quickly. They have more kinetic energy than the molecules of the cooler pot. Contact between pot and burner causes the molecules of the hot burner to collide with the slower molecules of the cool pot. The collisions result in a transfer of kinetic energy.

The molecules of the cooler pot start to vibrate faster, gaining kinetic energy. The molecules of the hot burner vibrate slower, losing kinetic energy.

This transfer of heat by contact is called conduction.

Figure 5.9 There are three forms of heat transfer shown in this diagram. After reading pages 88–89, identify each one.

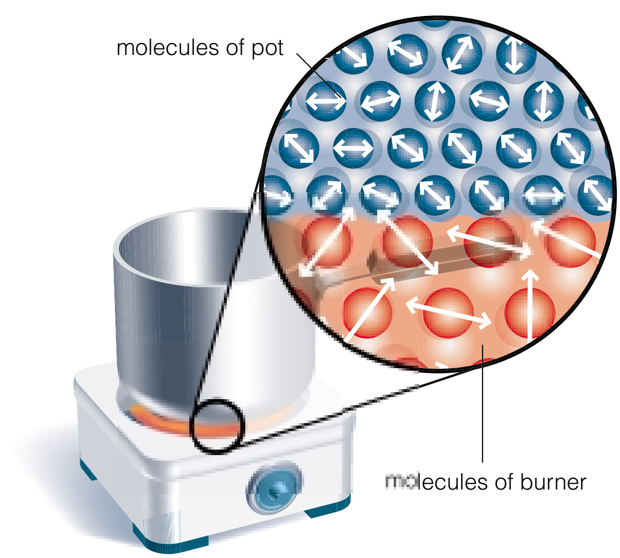


Figure 5.10 Conduction is a method of heat transfer that requires *contact*. Contact between warm molecules and colder molecules causes a transfer of kinetic energy.

Convection

If you hold your hand above the hot burner of a stove, you will feel a warm current of air. Why?

Heat is transferred, by conduction, from the hot burner to the air molecules touching the burner. These air molecules gain kinetic energy, vibrate faster, and get farther apart. These warm molecules are farther apart than cooler ones, so the warm air is less dense than the cool air around it. This warm air rises, making the warm current that you feel. Cool, denser air rushes in to take the place of the warm air.

Because of this continuous air flow, all the air in the room will become warmer. This transfer of heat by movement is called convection.

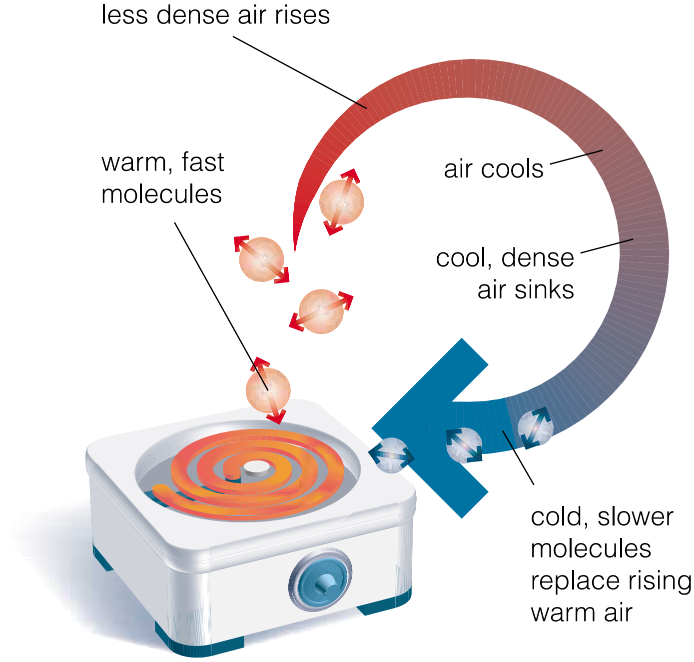


Figure 5.11 Convection is the *movement* of matter in the form of currents. Convection occurs only in liquids and gases.

Radiation

Look at the hand in Figure 5.12. The hand is close to the side of a burner but not above the burner. The front of the hand becomes warm while the back remains cool. The front of the hand is not being heated by conduction or convection. There is no contact with the burner and convection currents of warm air would rise away from the hand.

READING Check

Identify the three forms of heat transfer. Explain how heat is transferred in each.

The front of the hand is heated by radiation. Radiation is produced by vibrating electrons, which are tiny particles present in all atoms. This vibration makes a wave called an electromagnetic wave or infrared radiation wave. These waves are similar to the waves your hand can create when it vibrates in calm water. Waves or ripples run away from your moving hand.

Infrared radiation waves travel from the burner. They strike the hand and transfer heat energy to the molecules in the hand. This causes the molecules in the hand to vibrate faster.

DidYouKnow?

Hot objects warm cool ones until their temperatures are the same. Some people believe this evening out of heat will happen to the universe. According to the theory, the temperature of the entire universe will be the same eventually. When this happens, heat will no longer transfer. Without a source of energy, life will be impossible! This prediction is called the "Heat Death of the Universe."

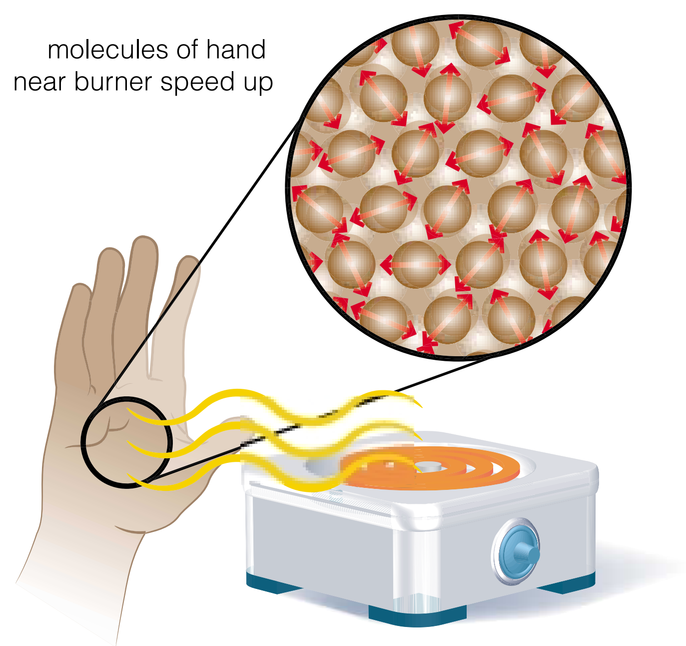


Figure 5.12 Radiation is the transfer of heat by electromagnetic waves.

CONDUCT AN

INVESTIGATION 5-B

SKILLCHECK

Initiating and Planning

Performing and Recording

Analyzing and Interpreting

Communication and Teamwork

Heat Conductivity Rate

On a cold morning, objects made of copper, glass, iron, and aluminum are placed outside. After one hour, all are at the same temperature. But they do not feel equally cold to the touch. Which object feels coldest? Which feels warmest?

To find out, compare the conduction rate of heat transfer through various substances.

Problem

What is the conduction rate of heat transfer through various substances?

Prediction

1. Predict which material will conduct heat the fastest: copper, glass, iron, or aluminum.
2. List these materials in order, from the fastest rate of heat transfer to the slowest. State any reasons for your prediction.

Safety Precautions

- Clean the equipment and wash your hands thoroughly at the end of the investigation.

Materials

matches

candle

Apparatus

Bunsen burner

2 clamps

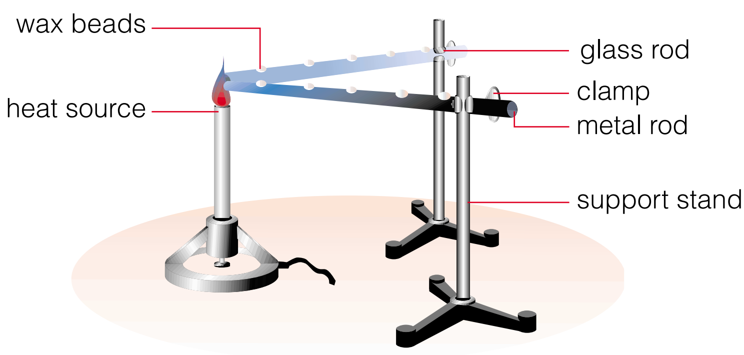
glass rod and metal rods of equal diameter and length

heat conductivity apparatus

2 support stands

timing device

ruler



Procedure

Part 1: Compare the Rates of Heat Transfer of Glass and Metal

1. Light the candle. Let it burn until there is some melted wax at the top. Tilt the candle carefully, and place drops of wax along the metal and the glass rods, one drop every 4 cm.

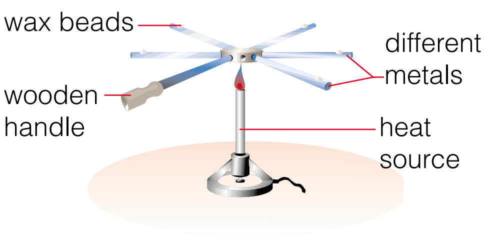
2. Use clamps to attach one end of each rod to a support stand.

3. Arrange the rods so that the free ends come together over the Bunsen burner flame.

- As the rods heat, observe the melting of the wax beads. Record your observations.

Part 2: Compare the Rate of Heat Transfer of Various Metals

1. Place a drop of wax on the *end* of each metal rod of the heat conductivity apparatus.
2. Secure the conductivity apparatus hub over the flame.
3. Time how long it takes for each wax bead to melt. Record your observations.



The metals to be tested are joined at one point

Analyze

1. What do your results tell you about the transfer of heat through metals and non-metals?

2. List the tested materials according to their ability to transfer heat, from fastest to slowest.

Conclude and Apply

3. Compare your results with your predictions. Can you explain any differences?

4. Describe three places in your home where you want a fast transfer of heat. List three situations where you want a slow transfer of heat.

5. While baking a cake, you want to avoid burning the bottom of the cake. Should you use a glass or a metal baking pan?

6. Why do some materials feel colder than others?

Check Your Understanding

1. There are three methods of heat energy transfer: conduction, convection, and radiation.
   (a) Which method can occur only in liquids and gases?
   (b) Which method can occur only if there is contact between two surfaces?
   (c) Which method can occur in a vacuum or in outer space?
2. A hot object is in contact with a cooler object.
   (a) Does thermal energy flow from the hot object to the cooler object?
   (b) Explain your answer.
3. As you stand in front of a bonfire, the flames warm you. Use what you have learned about heat transfer to explain:
   - why the part of your body facing the fire is warmer than the part facing away
   - why the flames and smoke rise
4. A metal spoon and a wooden spoon are placed in a refrigerator for several hours. Which will feel colder when it is taken out of the refrigerator? Why?

Key Terms

conduction
convection
radiation

5.4 Heat Transfer in Nature

Convection causes many weather phenomena, such as winds. You will study that in this section. You will also learn how climate, or average weather conditions based on long-term records, is affected by lakes and oceans. Complete Investigation 5–C to see how liquids and gases behave.

CONDUCT AN INVESTIGATION 5-C

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Heat Convection in Liquids and Gases: Teacher Demonstration

Problem

How is heat distributed in liquids and gases?

Prediction

Predict the best place to put a heating duct in a basement room. Justify your prediction.

Safety Precautions

- If the paper towel used in Part 2 begins to burn out of control, place it in the tin tray.
- When you have finished Part 2, place the smoking towel in the tin tray.

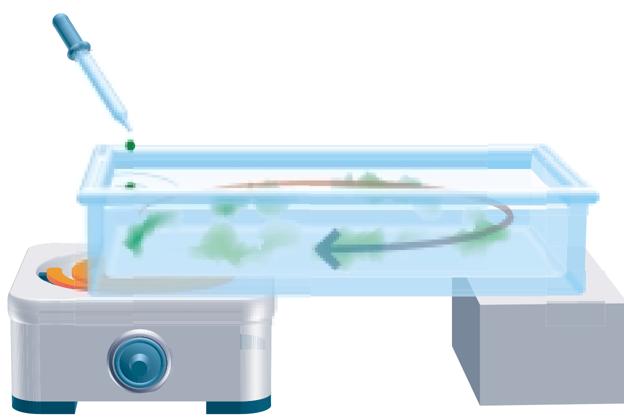
Apparatus

block of wood
gas convection apparatus
hot plate
large glass cooking pan
tin tray

Materials

food colouring
matches
paper towel
water

Procedure



Part 1: Observe Convection in a Liquid

1. Place the glass cooking dish as in the figure shown here. Put one end on the hot plate and the other end on the block of wood. Make sure that the baking pan is level.
2. Pour water into the baking pan until it is about full.
3. Turn the hot plate on low.
4. Add a drop of food colouring to the water above the hot plate.

5 Observe what happens to the colouring and record your observations.

Wipe up any spills and wash your hands thoroughly.

Part 2: Observe Convection in Air

1 Your teacher will set up the gas convection apparatus as shown.

2 Observe what happens to the smoke in the apparatus. Note your observations.

Analyze

Part 1

1. What happens to the food colouring over the hot plate?
2. What happens if you place the food colouring at the cold end of the cooking dish?

Part 2

3. What happens to the smoke over the cold chimney?
4. What happens to the smoke inside the gas convection apparatus?
5. What happens to the smoke in the hot chimney?

Conclude and Apply

6. Use your knowledge of convection of thermal energy. Explain the movement of water in the glass cooking pan.
7. Use your knowledge of convection of heat. Explain the movement of air in the gas convection apparatus.
8. What is the most effective location for heating ducts in a basement room? Does your answer confirm your initial prediction?

Extend Your Knowledge 

9. Name one situation where convection in liquids is important
10. Name one situation where convection in gases is important.
11. Brainstorm answers to questions 9 and 10 that have not been mentioned in this chapter.

Convection Currents and Weather

Many cottages are on the shores of lakes where convection currents keep the cottages cool in the daytime and warmer at night.

In the evening, the air over the water cools more slowly than the air over the land. Warm air from over the water rises and moves toward the land, keeping it warm. This is just like the dye moving from over the hot plate to the cool end of the cooking pan.

During the day, cool air from the lake moves toward the warm land in the same way that dye moved from the cold end of the cooking pan to the hot end.

Turn the page to learn the name of the convection currents and how they work.

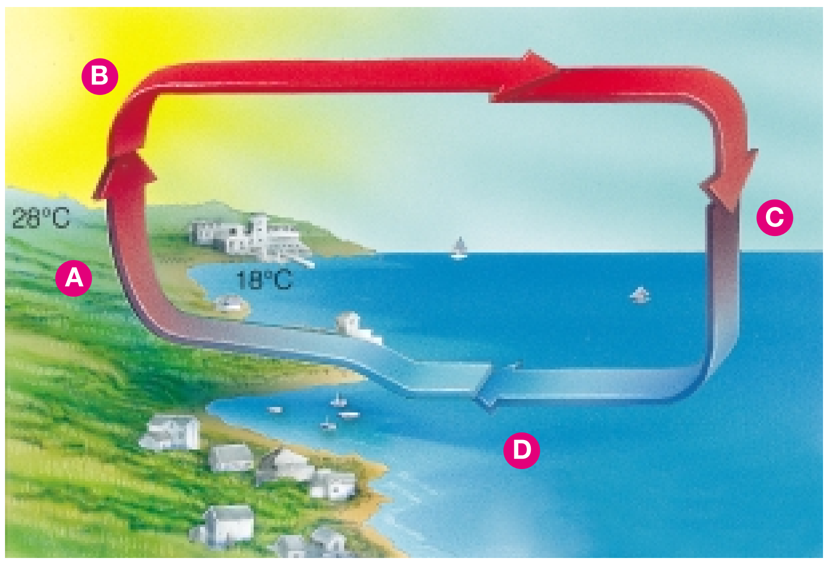
Sea and Land Breezes

You have demonstrated that warm air rises and cool air sinks. The circular movement that results was identified as convection. All the winds you ever feel start with convection currents. Here is how they work.

Land and sea breezes are convection currents of air that occur near a shoreline. They are both created by differences in temperature near the surface of Earth.

On a sunny day, radiant heat from the Sun strikes Earth's surface. Heat is absorbed by land and water. But land and water heat at different rates. Land heats quickly, but also cools quickly. Water heats slowly and takes longer to cool.

Sea Breeze



A. Sun's rays warm land more rapidly than they warm water.

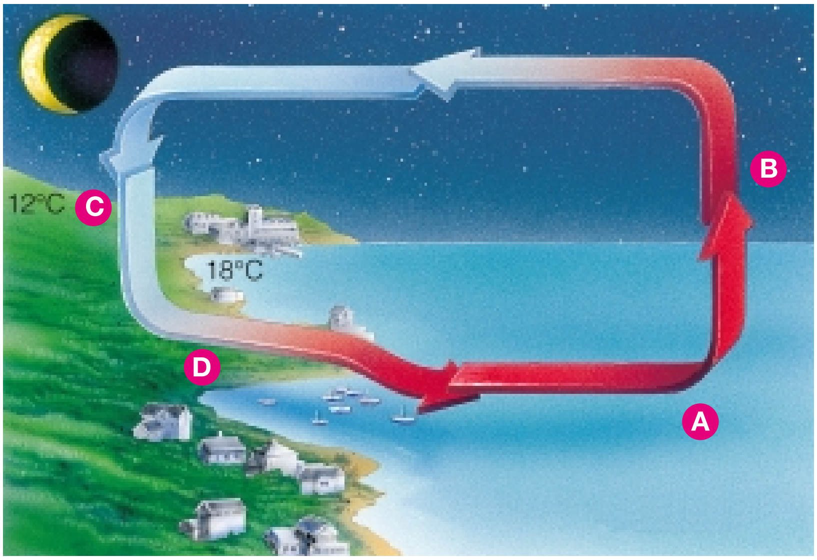
B. Warm air is less dense. Warm air rises.

C. Air over water is cooler. Cool air is more dense and sinks.

D. Cool air flows toward land to replace the warm air that has risen.

Figure 5.13A A **sea breeze** usually occurs on a hot summer day. If you are close to shore, you will feel a breeze blowing from sea to land. This is a sea breeze. A sea breeze is a cool wind that blows from an ocean or lake toward land. It is a cool and welcome relief on a hot day.

Land Breeze



A. The sea loses heat more slowly than the land. The air over the sea is warmer.

B. Warm air over the sea rises.

C. Air over land is cooler. Cool air is more dense and sinks.

D. Cool air flows toward the sea to replace the warm air that has risen.

Figure 5.13B A **land breeze** is a mild wind that flows from land to ocean. Land breezes usually occur in the evenings. Land breezes often serve to carry air pollutants out to sea, away from coastal cities. Land breezes are weaker than sea breezes because there is less temperature difference between the land and sea during the evening.

Try This!

Place thermometers into equal-sized containers of soil and water. Leave the containers in direct sunlight for several hours. Record the temperatures. Then place the containers in the shade for an hour. Note the temperatures. Do soil and water heat and cool at the same rate?

Reading Check

List or sketch the steps that produce a sea breeze.

Did You Know?

Mountain breezes affect the climate of Calgary. At night, air near the mountains cools, sinks, and flows toward the valleys in Calgary. This mountain breeze cools the city.

Why does Grande Prairie have so many thunderstorms? The answer is in the number of shallow lakes nearby.

The shallow lakes quickly heat up during sunny days. Warm lake water heats the air, causing it to rise. As the air rises, it cools and sinks back to the lake.

This cycle of rising and sinking air builds convection currents. These currents often create the thunderstorms so common in the area.

INVESTIGATION 5-D

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

How Oceans Affect Climate

Does being near a large body of water, such as an ocean or large lake, affect climate?

Think about it, and predict what you will find.

Analyze the climate data from several Canadian cities to see if your answer was correct.

Climate Pattern Statistics for Five Canadian Cities

City	Mean January Temperature (°C)	Mean July Temperature (°C)	Annual Precipitation (cm)	Average Annual Sunshine (hours)
Calgary, Alberta	-11	17	43.7	2208
Québec, Québec	-12	19	109.9	1708
Winnipeg, Manitoba	-18	20	53.5	2230
Regina, Saskatchewan	-17	19	39.8	2277
Vancouver, British Columbia	2	17	106.8	1931

What to Do

1. Oceans and large lakes are able to hold large amounts of thermal energy without much change in temperature. How is the temperature of the air above the ocean affected by the temperature of the ocean?

2. Using a map of Canada, locate the cities given in the table. Use a map of the world to notice that the cities are about the same distance north of the equator.

3. Use the data given to make four different bar graphs, one for each column of data. On each graph:
   - Place the names of the cities on the horizontal axis (x-axis).
   - Place the statistic you are analyzing on the vertical axis (y-axis).

Analyze

1. Compare the mean temperatures, annual precipitation, and number of annual sunshine hours in Vancouver to those in the other cities. What effect does nearness to the ocean seem to have?

2. Why is Vancouver warmer in winter than Calgary? Use your knowledge of heat transfers to explain.

Conclude and Apply

3. Use climate data to help you choose a place to live. Which city would you choose to live in if:

(a) You did not like cold temperatures?
(b) You wished to grow vegetables that require a lot of sunshine and water?
(c) You suffered from arthritis that causes severe joint pain when damp weather approaches?

How Oceans Help to Moderate Climates

Oceans are able to store large amounts of thermal energy. This prevents the area around them from having extreme temperature changes. Oceans **moderate** the climate of land areas near them. This means that they prevent the area from becoming either too hot or too cold. Here is how it works:

- In cool weather, an ocean can release a great amount of heat without cooling much itself. Even during very hot or very cold days, and as seasons change, the temperature of oceans remains constant.
- As the Sun warms air above the ocean, heat flows from the air into the water, cooling the air. When the temperature of the air above the ocean cools, heat flows from ocean to air and warms the air.

You could say oceans prevent land near them from getting very warm or very cold. Because of this, coastal cities like Vancouver have moderate climates.

Figure 5.14A Vancouver is beside the ocean and at the foot of mountains. How will this location affect its climate?

Figure 5.14B Calgary is inland and near mountains. How will this location affect its climate?

READING Check

Referring to a specific Canadian city, explain how oceans moderate climate.

Check Your Understanding

1. The city of Winnipeg is located near Lake Winnipeg, a large lake. Why does Winnipeg not experience much of a drop in temperature at the end of a hot day?
2. List or sketch the steps that produce a land breeze.
3. On a hot day, which place would be cooler? Explain why you think so.
   - a beach beside a large lake
   - 20 km away from the lake

Key Terms

sea breeze
land breeze
moderate

5.5 Heat Transfer and Technologies

Figure 5.15 Tea drinkers rinse an empty teapot with hot water before adding more hot water and tea. How might this affect the tea leaves and the temperature of the finished tea?

Try This!

Do dull, rough surfaces absorb heat more readily than smooth, shiny ones? Develop an investigation to find out.

Many household technologies either transfer or prevent the transfer of heat through conduction, convection, or radiation. That is why metal cooking pots have hard plastic or wooden handles. What other techniques are used to handle hot food?

Most cooks want to control how food is heated. Consider what happens when heating soup on a stove. The pot is heated by conduction through contact with the heating element. The soup at the bottom of the pot heats up first through conduction.

Heated soup rises to the top because it is less dense. Colder soup near the top of the pot flows to the bottom because it is denser. A circular motion in the soup results. These convection currents in the pot heat the soup to a uniform temperature.

Internet CONNECT

www.mcgrawhill.ca/links/science.connect1

Your home or apartment is heated using technologies designed to transfer heat by conduction, convection, and radiation. In most cases, a non-renewable energy source is used. Can renewable sources of energy be used instead? Can designers take advantage of solar energy to heat your home or school? To answer these and other questions, go to the above web site. Go to Internet Connects, Unit B, Chapter 5, and then to Renewable Energy.

When an oven is turned on, convection air currents move heat inside the oven. Air at the bottom of the oven is heated by burning gas or an electric element. Heated air becomes less dense and rises to the top of the oven. Cooler air sinks to the bottom.

The hot air heats the oven walls. These walls then radiate heat in all directions. In this way, food in the oven is cooked by both convection and radiation. There is also conduction from the baking pan.

Figure 5.16 Metal cooking pots and utensils are used around the world.

DidYouKnow?

Light-coloured surfaces reflect more heat than dark surfaces. This is why people in hot countries often wear white garments.

READING Check

Use a labelled sketch or diagram to show how an oven heats food.

Career CONNECT

Firefighters train constantly to learn how to control heat transfer. Training helps them do their job and protect their own life. If you have considered becoming a fire-fighter since you enjoyed playing with your first toy fire truck, you are now closer than ever. If you are in good physical condition and are working toward a high school diploma, the big steps are behind you.

The firefighter in the photo is trained to extinguish structural fires in a city. Her job is what most people think of as firefighting. But there is more. In Alberta, you can take special training to learn how to control wild-land fires. Also, Alberta has a worldwide reputation for expertise in extinguishing chemical and oil fires.

Any of these firefighting opportunities promise excitement and high interest.

Figure 5.17

Getting Rid of the Heat

Combustion of fuel inside an engine produces a large quantity of thermal energy. If this energy were not removed, the engine would overheat and be damaged. Here is how the engine is protected:

- The engine's cooling system contains a liquid coolant. Heat is conducted from the engine to the coolant.
- The coolant is pumped through the engine block to the radiator. A radiator is a honeycomb made of a metal alloy. The metal alloy is a good conductor. Heat from the coolant is conducted through this alloy to air.
- Either a fan or the motion of the vehicle forces this air through the radiator. Heat is transferred to the air that rushes through the radiator.

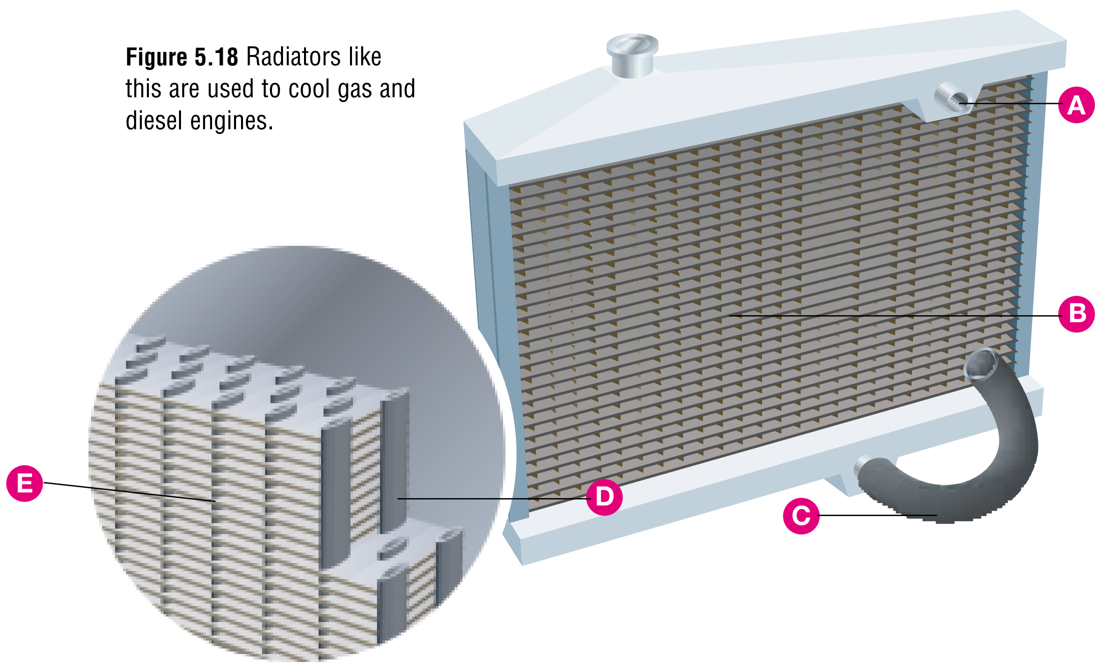
These three techniques use conduction to protect engines from heat damage.

READING Check

Sketch one device that protects against heat transfer. Explain how it works.

A. coolant input from engine
B. radiator core
C. coolant outlet to engine
D. tube
E. veins made of metal alloy

Figure 5.18 Radiators like this are used to cool gas and diesel engines.



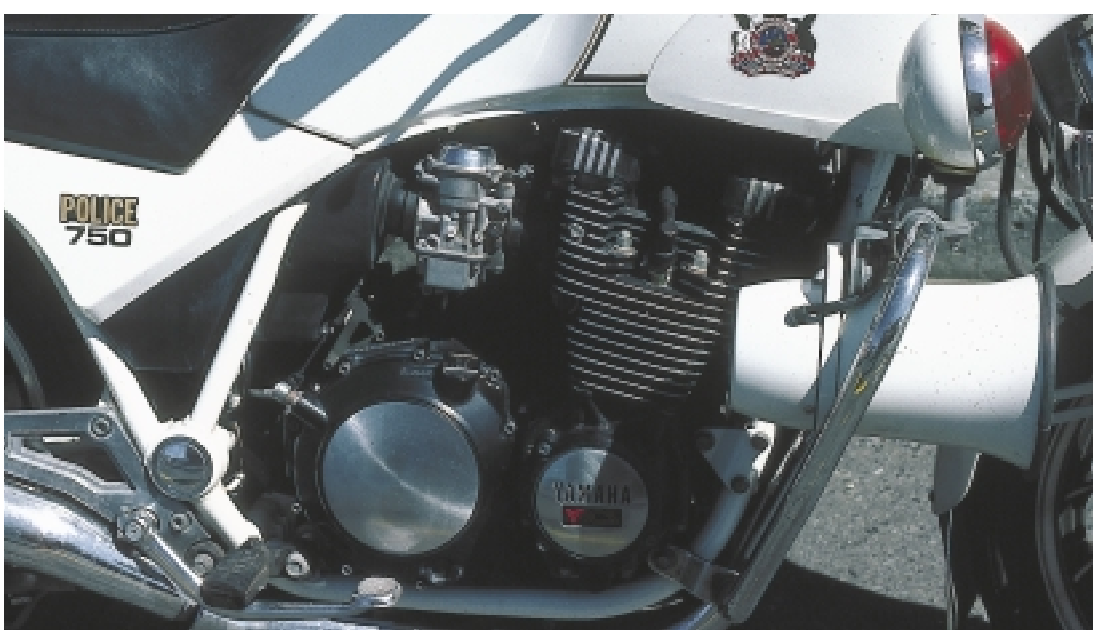
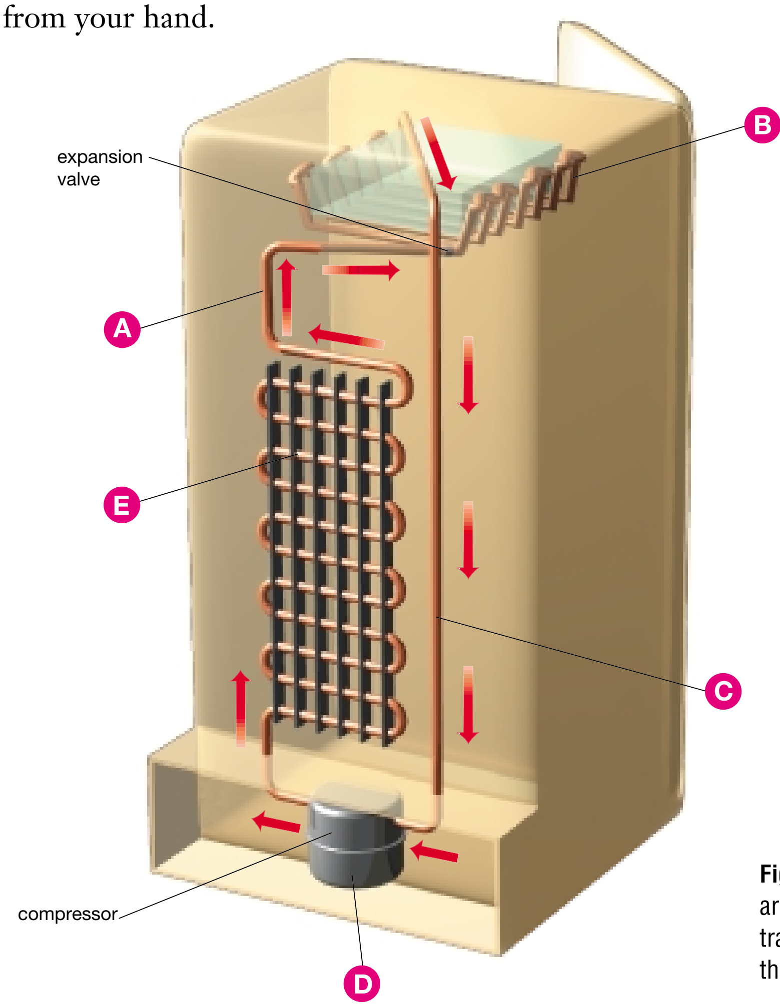


Figure 5.19 An air-cooled engine has no radiator. How do the fins on this engine keep it from overheating?

Keeping It Cool

When you put a little water on the back of your hand, your hand becomes cool. That is because thermal energy transfers from your hand to the water through conduction. Water absorbs heat from your hand and evaporates. Evaporation removes thermal energy as the water molecules leave the water droplets and move into the air. Your hand feels cooler.

This form of cooling is usually called cooling by evaporation. Evaporation caused the cooling, but the cooling action started with conduction of heat away from your hand.



Heat Transfer in a Refrigerator

A. A fluid called a coolant circulates through the pipes.

B. Heat from the food transfers to the cooler air surrounding it. Thermal energy then transfers from the air to the coolant.

C. The coolant evaporates as it gets warmer. It is pumped to the compressor.

D. When it reaches the compressor, pressure is applied to change it back into a liquid.

E. The liquid coolant is pumped to these coils. Thermal energy is released into the room. The cycle starts again.

Figure 5.20 Feel the pipes on the back of a fridge. They are hot. Heat from the items inside the fridge has been transferred to these pipes. The warm pipes release the thermal energy into the room.

Check Your Understanding

1. List the transfers of energy involved in boiling water in a pot. Describe each transfer.
2. Explain how three kinds of energy transfer are used in an oven when you bake bread.
3. Suppose you are given two cups of hot chocolate. One cup is made of shiny metal, and the other cup is made of a metal that has been painted black. Which cup will keep your hot chocolate warm longer? Explain.
4. Describe two ways of cooling gasoline engines.

CHAPTER

5 Review

Key Terms

friction
Robert Brown
Brownian motion
heat
thermal energy
kinetic energy
temperature
conduction
convection
radiation
sea breeze
land breeze
moderate

Reviewing Key Terms

If you need to review, the section numbers show you where these terms were introduced.

1. In your notebook, write the correct term to complete the following sentences:

(a) The sum of all the kinetic energies of an object is its __________ . (5.2)

(b) The average of all the kinetic energies of an object is its __________ . (5.2)

(c) The energy due to motion of particles in an object is its __________ . (5.2)

(d) A process of heat transfer that occurs when two objects are in contact with each other is __________ . (5.3)

(e) The process that releases heat when two objects rub together is __________ . (5.1)

(f) The first person to observe a sign of molecular motion was __________ . (5.1)

(g) A process of heat transfer that involves the circular flow of air or liquids is called __________ . (5.3)

(h) A process of heat transfer that involves electromagnetic waves is called __________ . (5.3)

(i) A wind that occurs as a result of air flowing from the land to the sea is called a __________ . (5.4)

(j) Oceans keep land near them from having temperature extremes. We say that oceans __________ temperatures. (5.4)

(k) A wind that occurs as a result of air flowing from the sea to the land is called a __________ . (5.3)

(l) A jiggling motion of small particles in water is called __________ . (5.1)

Understanding Key Ideas

Section numbers are provided if you need to review.

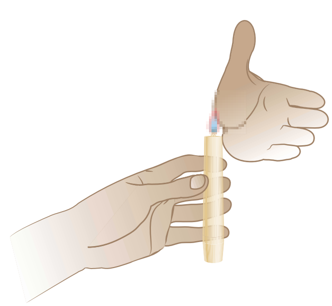
2. What theory did Brown suggest to explain the nature of heat? (5.1)

3. You take the temperature at various locations in a container of water. You find the temperature is the same at all locations. Are all the particles of water vibrating at the same speed? (5.2)

4. You hold a burning candle in one hand. Which of the three processes of heat transfer occurs in each of the following situations? (5.4)

(a) Your other hand is held high above the burning candle and feels heat.

(b) Your other hand is held near to the side of the flame. The front of your hand feels heat.



(c) A drop of wax falls on your hand and you feel heat.

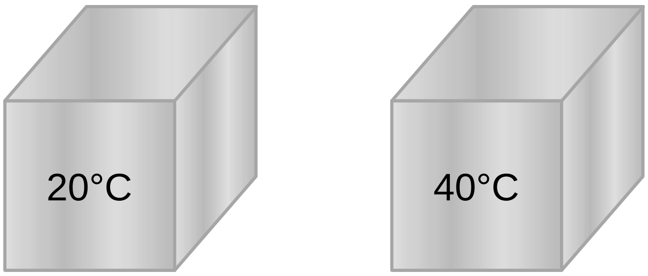
5. Why do land breezes occur during the evening? (5.4)
6. Toronto, Ontario is beside Lake Ontario. The temperature there does not drop much at night, after a hot day. Why is this? (5.4)
7. Use a sketch to show why hot air registers are placed on the floor and air conditioning outlets are placed near the ceiling. (5.4)

Developing Skills

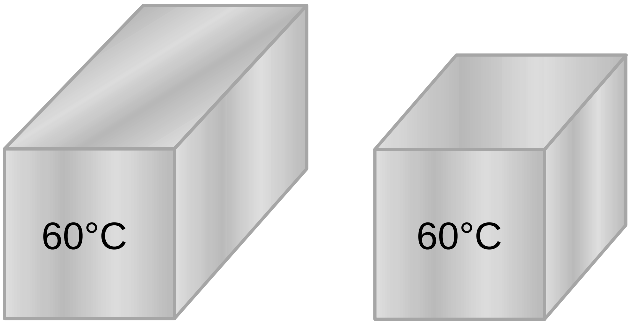
8. A boat in a harbour on a hot sunny day has a flag hanging from the mast. (5.4)
   (a) In what direction will the flag blow at noon?
   (b) Which way will it blow just after sunset?

Problem Solving/Applying

9. Look at the identical objects below. In which object is the average kinetic energy of the particles greater? Explain. (5.2)



10. Look at the objects below. Do their particles have the same average kinetic energy? Which object has more heat? Explain. (5.2)



11. You are planning a holiday to an area with a hot climate. Describe some clothes you should take with you. Explain why they will keep you cool. (5.3)
12. You open the hood of an overheated car. Draw a diagram showing where conduction, convection, and radiation of heat are taking place. (5.5)

Critical Thinking

13. James Prescott Joule measured water temperature at the top and then at the bottom of a waterfall. Would he have detected a difference in temperature? Explain your answer. (5.5)
14. A vacuum has nothing in it: no air, no liquid. Do you think it is possible to measure the temperature of a vacuum? Explain your answer. (5.3)

Pause & Reflect

1. Take another look at the chapter opener on page 80. List some concerns about heat that a climber must consider.
2. Check your original answers to the Getting Ready questions on page 80. How has your thinking changed? How would you answer these questions now that you have investigated the topics in this chapter?