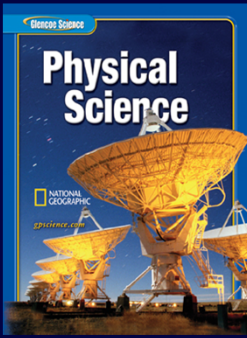


6



Physical Science

NATIONAL GEOGRAPHIC

CHAPTER RESOURCES

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CHAPTER RESOURCES

END

Temperature and Heat

6.1 Temperature

- You use the words hot and cold to describe temperature.
- Something is hot when its temperature is high.
- When you heat water on a stove, its temperature increases.
- How are temperature and heat related?

CHAPTER RESOURCES

END

Temperature and Heat

6.1 Matter in Motion

- The matter around you is made of tiny particles—atoms and molecules.
- In all materials these particles are in constant, random motion; moving in all directions at different speeds.


CHAPTER RESOURCES

END

Temperature and Heat

6.1 Matter in Motion

- The faster they move, the more kinetic energy they have.
- This figure shows that particles move faster in hot objects than in cooler objects.



CHAPTER RESOURCES

END

Temperature and Heat

6.1 Temperature

- The **temperature** of an object is a measure of the average kinetic energy of the particles in the object.
- As the temperature of an object increases, the average speed of the particles in random motion increases.


CHAPTER RESOURCES

END

Temperature and Heat

6.1 **Temperature**

- In SI units, temperature is measured in kelvins (K).
- A more commonly used temperature scale is the Celsius scale.



- One kelvin is the same as one degree Celsius.

CHAPTER RESOURCES

Temperature and Heat

6.1 **Thermal Energy**

- If you let cold butter sit at room temperature for a while, it warms and becomes softer.



- Because the air in the room is at a higher temperature than the butter, particles in air have more kinetic energy than butter particles.

CHAPTER RESOURCES

Temperature and Heat

6.1 **Thermal Energy**

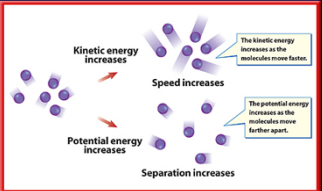
- Collisions between particles in butter and particles in air transfer energy from the faster-moving particles in air to the slower-moving butter particles.
- The butter particles then move faster and the temperature of the butter increases.

CHAPTER RESOURCES

Temperature and Heat

6.1 **Thermal Energy**

- The sum of the kinetic and potential energy of all the particles in an object is the **thermal energy** of the object.

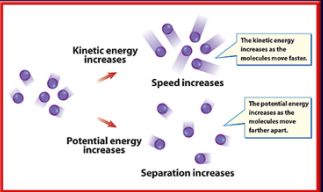


CHAPTER RESOURCES

Temperature and Heat

6.1 **Thermal Energy**

- Because the kinetic energy of the butter particles increased as it warmed, the thermal energy of the butter increased.



CHAPTER RESOURCES

Temperature and Heat

6.1 **Thermal Energy and Temperature**


- When the temperature of an object increase, the average kinetic energy of the particles in the object increases.
- Because thermal energy is the total kinetic and potential energy of all the particles in an object, the thermal energy of the object increases when the average kinetic energy of its particles increases.

CHAPTER RESOURCES

Temperature and Heat

6.1 **Thermal Energy and Mass**

- Suppose you have a glass and a beaker of water that are at the same temperature.
- The beaker contains twice as much water as the glass.
- The water in both containers is at the same temperature, so the average kinetic energy of the water molecules is the same in both containers.




CHAPTER RESOURCES

END

Temperature and Heat

6.1 **Thermal Energy and Mass**

- There are twice as many water molecules in the beaker as there are in the glass. So the total kinetic energy of all the molecules is twice as large for the water in the beaker.




CHAPTER RESOURCES

END

Temperature and Heat

6.1 **Thermal Energy and Mass**

- As a result, the water in the beaker has twice as much thermal energy as the water in the glass does.
- If the temperature doesn't change, the thermal energy in an object increases if the mass of the object increases.



CHAPTER RESOURCES

END

Temperature and Heat

6.1 **Heat**

- Heat** is thermal energy that flows from something at a higher temperature to something at a lower temperature.
- Heat is a form of energy, so it is measured in joules—the same units that energy is measured in.
- Heat always flows from warmer to cooler materials.

CHAPTER RESOURCES

END

Temperature and Heat

6.1 **Specific Heat**

- As a substance absorbs heat, its temperature change depends on the nature of the substance, as well as the amount of heat that is added.
- The amount of heat that is needed to raise the temperature of 1 kg of some material by 1°C is called the **specific heat** of the material.
- Specific heat is measured in joules per kilogram Kelvin [J/(kg °C)].

CHAPTER RESOURCES

END

Temperature and Heat

6.1 **Water as a Coolant**

- Compared with the other common materials in the table, water has the highest specific heat.
- The specific heat of water is high because water molecules form strong bonds with each other.

Specific Heat of Some Common Materials	
Substance	Specific Heat [J/(kg°C)]
Water	4,184
Wood	1,760
Carbon (graphite)	710
Glass	664
Iron	450

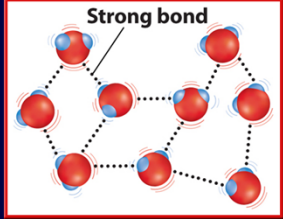
CHAPTER RESOURCES

END

Temperature and Heat

**6.1 Water as a Coolant**

- When heat is added, some of the added heat has to break some of these bonds before the molecules can start moving faster.



CHAPTER RESOURCES

END

Temperature and Heat

**6.1 Water as a Coolant**

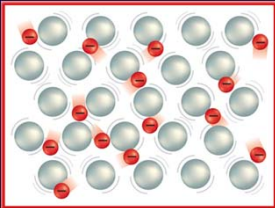
- Because water can absorb heat without a large change in temperature, it is useful as a coolant.
- A coolant is a substance that is used to absorb heat.
- Compared to other materials, the temperature of water will increase less.

CHAPTER RESOURCES

END

Temperature and Heat

**6.1 Water as a Coolant**



- In metals, electrons can move freely. When heat is added, no strong bonds have to be broken before the electrons can start moving faster.

CHAPTER RESOURCES

END

Temperature and Heat

**6.1 Changes in Thermal Energy**

- The thermal energy of an object changes when heat flows into or out of the object.
- If  $Q$  is the change in thermal energy and  $C$  is specific heat, the change in thermal energy can be calculated from the following equation:

**Thermal Energy Equation**

change in thermal energy (J) =  
 mass (kg) × change in temperature (°C) × specific heat  $\left(\frac{\text{J}}{\text{kg}^\circ\text{C}}\right)$

$$Q = m(T_f - T_i)C$$

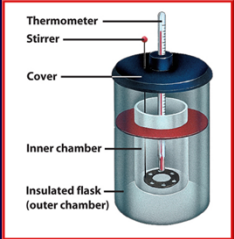
CHAPTER RESOURCES

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Temperature and Heat

**6.1 Measuring Specific Heat**

- The specific heat of a material can be measured using a device called a calorimeter.
- In a calorimeter, a heated sample transfers heat to a known mass of water.



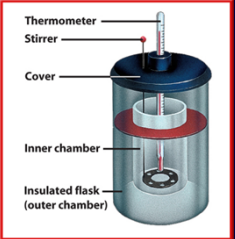
CHAPTER RESOURCES

END

Temperature and Heat

**6.1 Measuring Specific Heat**

- The energy absorbed by the water can be calculated by measuring the water's temperature change.
- Then the thermal energy released by the sample equals the thermal energy absorbed by the water.



CHAPTER RESOURCES

END

Section Check

6.1

**Question 1**

How is temperature related to kinetic energy?

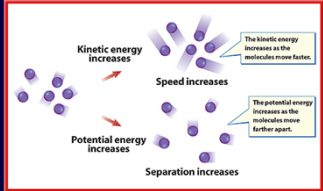
CHAPTER RESOURCES

END

Section Check

6.1

**Answer**



Temperature is a measure of the average kinetic energy of the particles in an object or material. As the temperature increases, the average speed of the particles increases.

CHAPTER RESOURCES

END

Section Check

6.1

**Question 2**

How is temperature related to kinetic energy?

**Answer**

Thermal energy is the sum of the kinetic and potential energy of all the particles in an object.

CHAPTER RESOURCES

END

Section Check

6.1

**Question 3**

The amount of heat that is needed to raise the temperature of 1 kg of a material by 1° C is called the \_\_\_\_\_ of the material.

A. density  
B. mass  
C. specific heat  
D. thermal energy

CHAPTER RESOURCES

END

Section Check

6.1

**Answer**

The answer is C. Specific heat is measured in joules/kilogram °C

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2

**Conduction**

- Thermal energy is transferred from place to place by conduction, convection, and radiation.
- Conduction** is the transfer of thermal energy by collisions between particles in matter.
- Conduction occurs because particles in matter are in constant motion.

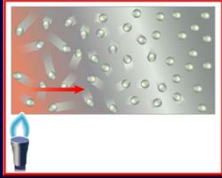
CHAPTER RESOURCES

END

Transferring Thermal Energy

**6.2 Collisions Transfer Thermal Energy**

- Thermal energy is transferred when one end of a metal spoon is heated by a Bunsen burner.



- The kinetic energy of the particles near the flame increases.

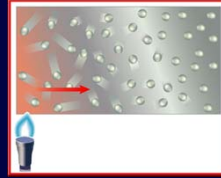
CHAPTER RESOURCES

END

Transferring Thermal Energy

**6.2 Collisions Transfer Thermal Energy**

- Kinetic energy is transferred when these particles collide with neighboring particles.



- As these collisions continue, thermal energy is transferred from one end of the spoon to the other end of the spoon.

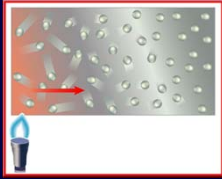
CHAPTER RESOURCES

END

Transferring Thermal Energy

**6.2 Collisions Transfer Thermal Energy**

- When heat is transferred by conduction, thermal energy is transferred from place to place without transferring matter.



- Thermal energy is transferred by the collisions between particles, not by movement of matter.

CHAPTER RESOURCES

END

Transferring Thermal Energy

**6.2 Heat Conductors**

- The rate at which heat moves depends on the material.
- Heat moves faster by conduction in solids and liquids than in gases.
- In gases, particles are farther apart, so collisions with other particles occur less frequently than they do in solids or liquids.


CHAPTER RESOURCES

END

Transferring Thermal Energy

**6.2 Heat Conductors**

- The best conductors of heat are metals.



- In a piece of metal, there are electrons that are not bound to individual atoms, but can move easily through the metal.


CHAPTER RESOURCES

END

Transferring Thermal Energy

**6.2 Heat Conductors**

- Collisions between these electrons and other particles in the metal enable thermal energy to be transferred more quickly than in other material.



CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Convection**

- Liquids and gases can flow and are classified as fluids.
- In fluids, thermal energy can be transferred by convection.
- Convection** is the transfer of thermal energy in a fluid by the movement of warmer and cooler fluid from place to place. 🗣️

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Convection**

- When conduction occurs, more energetic particles collide with less energetic particles and transfer thermal energy.
- When convection occurs, more energetic particles move from one place to another.
- As the particles move faster, they tend to be farther apart.
- As a result, a fluid expands as its temperature increases.

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Convection**

- When a fluid expands, its volume increases, but its mass doesn't change.
- As a result, its density decreases.
- The same is true for parts of a fluid that have been heated.
- The density of the warmer fluid, therefore, is less than that of the surrounding cooler fluid.

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Heat Transfer by Currents**

- Convection currents transfer heat from warmer to cooler parts of the fluid.
- In a convection current, both conduction and convection transfer thermal energy.

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Desert and Rain Forests**

- Earth's atmosphere is made of various gases and is a fluid.
- The atmosphere is warmer at the equator than it is at the north and south poles.
- These temperature differences create convection currents that carry heat to cooler regions.

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Radiation**

- Almost no matter exists in the space between Earth and the Sun, so heat cannot be transferred by conduction or convection. Instead, the Sun's heat reaches Earth by radiation.

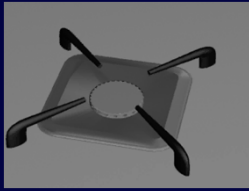
CHAPTER RESOURCES

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Transferring Thermal Energy

6.2 **Radiation**

- Radiation** is the transfer of energy by electromagnetic waves.



Click image to play movie

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Radiation**

- These waves can travel through space even when no matter is present.
- Energy that is transferred by radiation often is called radiant energy.


CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Radiant Energy and Matter**

- When radiation strikes a material, some of the energy is absorbed, some is reflected, and some may be transmitted through the material.




CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Radiant Energy and Matter**

- The amount of energy absorbed, reflected, and transmitted depends on the type of material.
- Materials that are light-colored reflect more radiant energy, while dark-colored materials absorb more radiant energy.




CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Radiant Energy and Matter**

- When radiant energy is absorbed by a material, the thermal energy of the material increases.



CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Radiation in Solids, Liquids, and Gases**

- The transfer of energy by radiation is most important in gases.
- In a solid, liquid or gas, radiant energy can travel through the space between molecules.
- Molecules can absorb this radiation and emit some of the energy they absorbed.

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Radiation in Solids, Liquids, and Gases**

- This energy then travels through the space between molecules, and is absorbed and emitted by other molecules.
- Because molecules are much farther apart in gases than in solids or liquids, radiation usually passes more easily through gases than through solids or liquids.


CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Controlling Heat Flow**

- Almost all living things have special features that help them control the flow of heat.
- For example, the Antarctic fur seal's thick coat helps keep it from losing heat. This helps them survive in a climate in which the temperature is often below freezing.




CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Controlling Heat Flow**

- In the desert the scaly skin of the desert spiny lizard has just the opposite effect.



- It reflects the Sun's rays and keeps the animal from becoming too hot.

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Insulators**

- A material in which heat flows slowly is an **insulator**.
- Examples of materials that are insulators are wood, some plastics, fiberglass, and air.
- Material, such as metals, that are good conductors of heat are poor insulators.

CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Insulators**

- Gases, such as air, are usually much better insulators than solids or liquids.
- Some types of insulators contain many pockets of trapped air.
- These air pockets conduct heat poorly and also keep convection currents from forming.


CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Insulating Buildings**

- Building insulation is usually made of some fluffy material, such as fiberglass, that contains pockets of trapped air.



- The insulation is packed into a building's outer walls and attic, where it reduces the flow of heat between the building and the surrounding air.


CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Reducing Heat Flow in a Thermos**

- A thermos bottle reduces the flow of heat into and out of the liquid in the bottle, so that the temperature of the liquid hardly changes over a number of hours.
- To do this, a thermos bottle has two glass walls.



Outer case  
Vacuum  
Reflective surface


CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Reducing Heat Flow in a Thermos**

- The air between the two walls is removed so there is a vacuum between the glass layers.
- Because the vacuum contains almost no matter, it prevents heat transfer by conduction or radiation between the liquid and the air outside the thermos.



Outer case  
Vacuum  
Reflective surface


CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Reducing Heat Flow in a Thermos**

- To further reduce the flow of heat into or out of the liquid, the inside and outside glass surface of a thermos bottle is coated with aluminum to make each surface highly reflective.
- This causes electromagnetic waves to be reflected at each surface.



Outer case  
Vacuum  
Reflective surface


CHAPTER RESOURCES

END

Transferring Thermal Energy

6.2 **Reducing Heat Flow in a Thermos**

- The inner reflective surface prevents radiation from transferring heat out of the liquid.
- The outer reflective surface prevents radiation from transferring heat into the liquid.



Outer case  
Vacuum  
Reflective surface

CHAPTER RESOURCES

END

Section Check

6.2

**Question 1**

Describe the difference between conduction and convection.

CHAPTER RESOURCES

END

Section Check

6.2

**Answer**

Conduction transfers thermal energy without transferring matter. In convection, the more energetic particles move from one place to another.

CHAPTER RESOURCES

END

Section Check

**6.2**

**Question 2**

\_\_\_\_\_ is the transfer of energy by electromagnetic waves.

**Answer**

The transfer of energy by electromagnetic waves is radiation. Radiation is how Earth gets heat from the Sun.

CHAPTER RESOURCES

END

Section Check

**6.2**

**Question 3**

Which of the following is the least effective insulator?

A. air  
B. fiberglass  
C. metal  
D. wood

CHAPTER RESOURCES

END

Section Check

**6.2**

**Answer**

The answer is C. Metals are good conductors of heat.

CHAPTER RESOURCES


END

Using Heat

**6.3**

**Heating Systems**

- Most homes and public buildings contain some type of heating system.
- In the simplest and oldest heating system, wood or coal is burned in a stove.



CHAPTER RESOURCES


END

Using Heat

**6.3**

**Heating Systems**

- The heat that is produced by the burning fuel is transferred from the stove to the surrounding air by conduction, convection, and radiation.
- One disadvantage of this system is that heat transfer from the room in which the stove is located to other rooms in the building can be slow.



CHAPTER RESOURCES

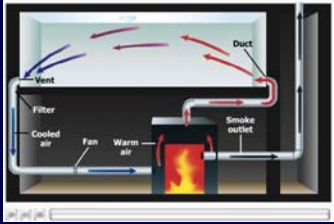
END

Using Heat

**6.3**

**Forced-Air Systems**

- The most common type of heating system in use today is the forced-air system.



MAC OS X users click here to view.

CHAPTER RESOURCES

END

Using Heat

6.3 **Radiator Systems**

- A radiator is a closed metal container that contains hot water or steam.
- The thermal energy contained in the hot water or steam is transferred to the air surrounding the radiator by conduction.
- This warm air then moves through the room by convection.

CHAPTER RESOURCES

END

Using Heat

6.3 **Radiator Systems**

- In radiator heating systems, fuel burned in a central furnace heats a tank of water.
- A system of pipes carries the hot water to radiators in the rooms of the building.
- After the water cools, it flows through the pipes back to the water tank, and is reheated.

CHAPTER RESOURCES

END

Using Heat

6.3 **Electric Heating Systems**

- An electric heating system has no central furnace.
- Instead, electrically heated coils placed in floors and in walls heat the surrounding air by conduction.
- Heat is then distributed through the room by convection.

CHAPTER RESOURCES

END

Using Heat

6.3 **Solar Heating**

- The radiant energy from the Sun can be used to help heat homes and buildings.
- There are two types of systems that use the Sun's energy for heating—passive solar heating systems and active solar heating systems.


CHAPTER RESOURCES

END

Using Heat

6.3 **Passive Solar Heating**

- In passive solar heating systems, materials inside a building absorb radiant energy from the Sun during the day and heat up.
- At night when the building begins to cool, thermal energy absorbed by these materials helps keep the room warm.



CHAPTER RESOURCES

END

Using Heat

6.3 **Active Solar Heating**

- Active solar heating systems use **solar collectors** that absorb radiant energy from the Sun.
- The collectors usually are installed on the roof or south side of a building.
- Radiant energy from the Sun heats air or water in the solar collectors.

CHAPTER RESOURCES

END

Using Heat

**6.3 Active Solar Heating**

- The black metal plate absorbs radiant energy from the Sun.
- The absorbed energy heats water in pipes just above the plate.

Glass sheets  
Pipes for liquid  
Black metal plate insulation

CHAPTER RESOURCES

END

Using Heat

**6.3 Active Solar Heating**

- A pump circulates the hot water to radiators in rooms of the house.
- The cooled water then is pumped back to the collector to be reheated.

Glass sheets  
Pipes for liquid  
Black metal plate insulation

CHAPTER RESOURCES

END

Using Heat

**6.3 Thermodynamics**

- Thermal energy, heat, and work are related, and the study of the relationship among them is **thermodynamics**.

CHAPTER RESOURCES

END

Using Heat

**6.3 Heat and Work Increase Thermal Energy**

- You can warm your hands by placing them near a fire, so that heat is added to your hands by radiation.
- If you rub your hands and hold them near a fire, the increase in thermal energy of your hand is even greater.

CHAPTER RESOURCES

END

Using Heat

**6.3 Heat and Work Increase Thermal Energy**

- Both the work you do and the heat transferred from the fire increase the thermal energy of your hands.

CHAPTER RESOURCES

END

Using Heat

**6.3 Heat and Work Increase Thermal Energy**

- Your hands can be considered as a system.
- A system is anything you can draw a boundary around.


CHAPTER RESOURCES

END

Using Heat

6.3 **Heat and Work Increase Thermal Energy**

- The heat transferred to a system is the amount of heat flowing into the system that crosses the boundary.



- The work done on a system is the work done by something outside the system's boundary.

CHAPTER RESOURCES

END

Using Heat

6.3 **The First Law of Thermodynamics**

- According to the **first law of thermodynamics**, the increase in thermal energy of a system equals the work done on the system plus the heat transferred to the system.


CHAPTER RESOURCES

END

Using Heat

6.3 **The First Law of Thermodynamics**

- The temperature of a system can be increased by adding heat to the system, doing work on the system, or both.



- The increase in energy of a system equals the energy added to the system.

CHAPTER RESOURCES

END

Using Heat

6.3 **Closed and Open Systems**

- A system is an open system if heat flows across the boundary or if work is done across the boundary.
- Then energy is added to the system.
- If no heat flows across the boundary and there is no outside work done, then the system is a closed system.

CHAPTER RESOURCES

END

Using Heat

6.3 **Closed and Open Systems**

- The thermal energy of a closed system doesn't change.
- Because energy cannot be created or destroyed, the total energy stays constant in a closed system.

CHAPTER RESOURCES

END

Using Heat

6.3 **The Second Law of Thermodynamics**

- Can heat flow spontaneously from a cold object to a warm object?
- This process never happens, but it wouldn't violate the first law of thermodynamics.

CHAPTER RESOURCES

END

Using Heat

6.3 **The Second Law of Thermodynamics**

- The flow of heat spontaneously from a cool object to a warm object never happens because it violates another law—the second law of thermodynamics.
- One way to state the **second law of thermodynamics** is that it is impossible for heat to flow from a cool object to a warmer object unless work is done. 🔊

CHAPTER RESOURCES

Using Heat

6.3 **Converting Heat to Work**

- If you give a book sitting on a table a push, the book will slide and come to a stop.
- Friction between the book and the table converted the work you did on the book to heat.
- As a result, the book and the table became slightly warmer.

CHAPTER RESOURCES

Using Heat

6.3 **Converting Heat to Work**

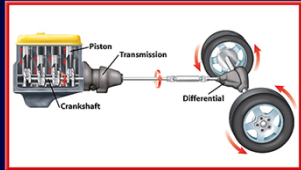
- Is it possible to do the reverse, and convert heat completely into work?
- The second law of thermodynamics makes it impossible to build a device that converts heat completely into work.

CHAPTER RESOURCES

Using Heat

6.3 **Converting Heat to Work**

- A device that converts heat into work is a **heat engine**. 🔊



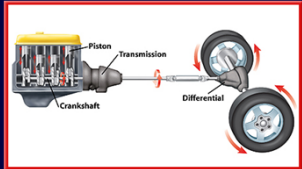
- A car's engine converts the chemical energy in gasoline into heat.

CHAPTER RESOURCES

Using Heat

6.3 **Converting Heat to Work**

- The engine then transforms some of the thermal energy into work by rotating the car's wheels.



CHAPTER RESOURCES

Using Heat

6.3 **Converting Heat to Work**

- However, only about 25 percent of the heat released by the burning gasoline is converted into work, and the rest is transferred to the engine's surroundings.

CHAPTER RESOURCES

Using Heat

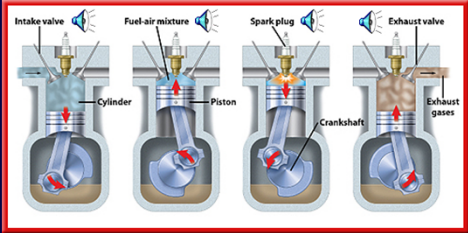
6.3 **Internal Combustion Engines**

- The heat engine in a car is an **internal combustion engine** in which fuel is burned inside the engine in chambers or cylinders.
- Each cylinder contains a piston that moves up and down.
- Each up-and-down movement of the piston is called a stroke.
- Automobile and diesel engines have four different strokes.

CHAPTER RESOURCES

Using Heat

6.3 **Internal Combustion Engines**



The diagram illustrates the four strokes of an internal combustion engine. 1. Intake stroke: The intake valve is open, and the piston moves down, drawing in a fresh fuel-air mixture. 2. Compression stroke: Both valves are closed, and the piston moves up, compressing the mixture. 3. Combustion stroke: The spark plug ignites the compressed mixture, forcing the piston down. 4. Exhaust stroke: The exhaust valve is open, and the piston moves up, pushing out the exhaust gases. Labels include: Intake valve, Fuel-air mixture, Spark plug, Exhaust valve, Cylinder, Piston, Crankshaft, and Exhaust gases.

CHAPTER RESOURCES

Using Heat

6.3 **Friction and the Efficiency of Heat Engines**

- Almost three fourths of the heat produced in an internal combustion engine is not converted into useful work.
- Friction between moving parts causes some of the work done by the engine to be converted into heat.

CHAPTER RESOURCES

Using Heat

6.3 **Friction and the Efficiency of Heat Engines**


- Even if friction were totally eliminated, a heat engine still could not convert heat completely into work and be 100 percent efficient.
- The efficiency of an internal combustion engine depends on the difference in the temperature of the burning gases in the cylinder and the temperature of the air outside the engine.

CHAPTER RESOURCES

Using Heat

6.3 **Heat Movers**

- A refrigerator does work as it moves heat from inside the refrigerator to the warmer room.
- The energy to do the work comes from the electrical energy the refrigerator obtains from an electrical outlet.



CHAPTER RESOURCES

Using Heat

6.3 **Refrigerators**

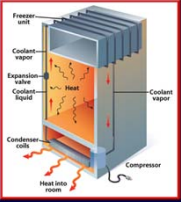
- A refrigerator contains a coolant that is pumped through pipes on the inside and outside of the refrigerator.
- The coolant is a special substance that evaporates at a low temperature.

CHAPTER RESOURCES

Using Heat

6.3 **Refrigerators**

- Liquid coolant is pumped through an expansion valve and changes into a gas.
- When the coolant changes to a gas, it cools.



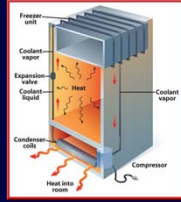
- The cold gas is pumped through pipes inside the refrigerator, where it absorbs thermal energy.
- As a result, the inside of the refrigerator cools.

CHAPTER RESOURCES

Using Heat

6.3 **Refrigerators**

- The gas then is pumped to a compressor that does work by compressing the gas.



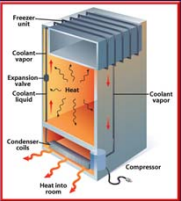
- This makes the gas warmer than the temperature of the room.
- The warm gas is pumped through the condenser coils.

CHAPTER RESOURCES

Using Heat

6.3 **Refrigerators**

- Because the gas is warmer than the room, thermal energy flows from the gas to the room.



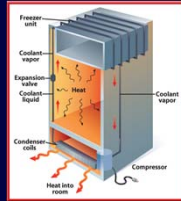
- Some of this heat is the thermal energy that the coolant gas absorbed from the inside of the refrigerator.

CHAPTER RESOURCES

Using Heat

6.3 **Refrigerators**

- As the gas gives off heat, it cools and changes to a liquid.




- The liquid coolant then is changed back to a gas, and the cycle is repeated.

CHAPTER RESOURCES

Using Heat

6.3 **Air Conditioners and Heat Pumps**

- An air conditioner operates like a refrigerator, except that warm air from the room is forced to pass over tubes containing the coolant.




- The warm air is cooled and is forced back into the room.
- The thermal energy that is absorbed by the coolant is transferred to the air outdoors.

CHAPTER RESOURCES

Using Heat

6.3 **Air Conditioners and Heat Pumps**

- A heat pump is a two-way heat mover.



- In warm weather, it operates as an air conditioner.
- In cold weather, a heat pump operates like an air conditioner in reverse.

CHAPTER RESOURCES

Using Heat

**6.3** **Air Conditioners and Heat Pumps**

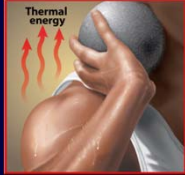
- The coolant gas is cooled and is pumped through pipes outside the house.
- There, the coolant absorbs heat from the outside air.
- The coolant is then compressed and pumped back inside the house, where it releases heat.

CHAPTER RESOURCES

Using Heat

**6.3** **The Human Coolant**

- Your body uses evaporation to keep its internal temperature constant.
- When a liquid changes to a gas, energy is absorbed from the liquid's surroundings.
- As you exercise, your body generates sweat from tiny glands within your skin. As the sweat evaporates, it carries away heat.



CHAPTER RESOURCES

Using Heat

**6.3** **Energy Transformations Produce Heat**

- Many energy transformations occur around you that convert one form of energy into a more useful form.
- However, usually when these energy transformations occur, some heat is produced.

CHAPTER RESOURCES

Section Check

**6.3** **Question 1**

The study of the relationship among thermal energy, heat and work is \_\_\_\_\_.

- electrical engineering
- graphical analysis
- specific heat
- thermodynamics

CHAPTER RESOURCES

Section Check

**6.3** **Answer**

The answer is D, thermodynamics.

CHAPTER RESOURCES

Section Check

**6.3** **Question 2**

According to \_\_\_\_\_, the increase in thermal energy of a system equals the work done on the system plus the heat transferred to the system.

- Newton's First Law
- Newton's Second Law
- the first law of thermodynamics
- the second law of thermodynamics





CHAPTER RESOURCES

Section Check

**6.3**

**Answer**

The answer is C. Doing work on a system is a way of adding energy to a system.


**CHAPTER RESOURCES**
  
**END**

Section Check





**6.3**

**Question 3**

How does a refrigerator work?

**Answer**




The refrigerator coolant absorbs thermal energy from inside the refrigerator and releases it into the surrounding air.






**CHAPTER RESOURCES**
  
**END**

Help





**6**

To advance to the next item or next page click on any of the following keys: mouse, space bar, enter, down or forward arrow.

-  Click on this icon to return to the table of contents
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-  Click on this icon to move to the next slide
- CHAPTER RESOURCES** Click on this icon to open the resources file.
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