
Vocabulary

1. energy - ability to do work
2. kinetic - of, relating to, or resulting from motion.
3. potential - having or showing the capacity to become or develop into something in the future.
4. thermal energy - Thermal energy is the internal energy of an object due to the kinetic energy of its atoms and/or molecules.
5. conductor - A material or an object that conducts heat, electricity, light, or sound.
6. insulator - a substance that does not readily allow the passage of heat or sound.
7. conduction - the process by which heat or electricity is directly transmitted through a substance when there is a difference of temperature or of electrical potential between adjoining regions, without movement of the material.
8. convection - the movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, and colder, denser material to sink under the influence of gravity, which consequently results in transfer of heat.
9. radiation - energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles that cause ionization.
10. electromagnetic waves - one of the waves that are propagated by simultaneous periodic variations of electric and magnetic field intensity and that include radio waves, infrared, visible light, ultraviolet, X-rays, and gamma rays.
11. reflection - as in casting back a light or heat, mirroring, or giving back or showing an image
12. refraction - change in direction of propagation of any wave as a result of its traveling at different speeds at different points along the wave front
13. wavelength - the distance between successive crests of a wave, especially points in a sound wave or electromagnetic wave.
14. electromagnetic radiation - a kind of radiation including visible light, radio waves, gamma rays, and X-rays, in which electric and magnetic fields vary simultaneously.
15. electromagnetic spectrum - the range of wavelengths or frequencies over which electromagnetic radiation extends.
16. infrared - (of electromagnetic radiation) having a wavelength just greater than that of the red end of the visible light spectrum but less than that of microwaves. Infrared radiation has a wavelength from about 800 nm to 1 mm, and is emitted particularly by heated objects.
17. ultraviolet - (of electromagnetic radiation) having a wavelength shorter than that of the violet end of the visible spectrum but longer than that of X-rays.
18. ozone - a colorless unstable toxic gas with a pungent odor and powerful oxidizing properties, formed from oxygen by electrical discharges or ultraviolet light.
19. visible spectrum - The visible spectrum is the portion of the electromagnetic spectrum that is visible to the human eye. Electromagnetic radiation in this range of wavelengths is called visible light or simply light.
1 Study Guide

6.P.3.1 Illustrate the transfer of heat energy from warmer objects to cooler ones using examples of conduction, radiation and convection and the effects that may result.

1. A. thermally
   B. mechanically
   C. electrically
   D. electromagnetic

2. thermal, heat, warm, cooler, conduction, convection, radiation, conduction, convection

3. Draw a picture which illustrates the three ways of heat transfer in matter. Student pictures may vary

<table>
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<th>Figure 2–Conduction, Convection, and Radiation</th>
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<td><strong>Conduction</strong></td>
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4. conductors, insulators

**Draw an illustration of each below.** Student drawings may vary.

conductor  insulator

5. conductors, conductor, insulator, conductors, insulators
Energy: Forms and Changes
DAY ONE: The Nature of Energy

- Energy is all around you!
  - You can hear energy as sound.
  - You can see energy as light.
  - And you can feel it as wind.
Nature of Energy

You use energy when you:
- hit a softball.
- lift your book bag.
- compress a spring.
Nature of Energy

Living organisms need energy for growth and movement.
Nature of Energy

- Energy is involved when:
  - a bird flies.
  - a bomb explodes.
  - rain falls from the sky.
  - electricity flows in a wire.
Nature of Energy

- What is energy that it can be involved in so many different activities?
  - Energy can be defined as the ability to do work.
  - If an object or organism does work (exerts a force over a distance to move an object) the object or organism uses energy.
Nature of Energy

- Because of the direct connection between energy and work, energy is measured in the same unit as work: joules (J).
- In addition to using energy to do work, objects gain energy because work is being done on them.
DAY TWO: The Forms of Energy

- The five main forms of energy are:
  - Thermal
  - Chemical
  - Electromagnetic
  - Nuclear
  - Mechanical
Thermal Energy

- The internal motion of the atoms is called heat energy, because moving particles produce heat.
- Thermal energy can be produced by friction.
- Thermal energy causes changes in temperature and phase of any form of matter.
Chemical Energy

- Chemical Energy is required to bond atoms together.
- And when bonds are broken, energy is released.
Chemical Energy

- Fuel and food are forms of stored chemical energy.
Electromagnetic Energy

- Power lines carry electromagnetic energy into your home in the form of electricity (electrical energy).
Electromagnetic Energy

- Light is a form of electromagnetic energy.
- Each color of light (Roy G Bv) represents a different amount of electromagnetic energy.
- Electromagnetic Energy is also carried by X-rays, radio waves, and laser light.
Nuclear Energy

- The nucleus of an atom is the source of nuclear energy.
Nuclear Energy

- When the nucleus splits (fission), nuclear energy is released in the form of heat energy and light energy.
- Nuclear energy is also released when nuclei collide at high speeds and join (fuse).
Nuclear Energy

The sun’s energy is produced from a nuclear fusion reaction in which hydrogen nuclei fuse to form helium nuclei.
Nuclear Energy

- Nuclear energy is the most concentrated form of energy.
Mechanical Energy

- When work is done to an object, it acquires energy. The energy it acquires is known as mechanical energy.
Mechanical Energy

- When you kick a football, you give mechanical energy to the football to make it move.
When you throw a balling ball, you give it energy. When that bowling ball hits the pins, some of the energy is transferred to the pins (transfer of momentum).
Energy can be changed from one form to another. Changes in the form of energy are called energy conversions.
Energy conversions

- All forms of energy can be converted into other forms.
  - The sun’s energy through solar cells can be converted directly into electricity.
  - Green plants convert the sun’s energy (electromagnetic) into starches and sugars (chemical energy).
In an electric motor, electromagnetic energy is converted to mechanical energy.

In a battery, chemical energy is converted into electromagnetic energy.

The mechanical energy of a waterfall is converted to electrical energy in a generator.
Energy Conversions

- In an automobile engine, fuel is burned to convert chemical energy into heat energy. The heat energy is then changed into mechanical energy.
DAY FOUR: The States of Energy

- The most common energy conversion is the conversion between potential and kinetic energy.
- All forms of energy can be in either of two states:
  - Potential
  - Kinetic
States of Energy: Kinetic and Potential Energy

- Kinetic Energy is the energy of motion.
- Potential Energy is stored energy.
Kinetic Energy

- The energy of motion is called kinetic energy.
- The faster an object moves, the more kinetic energy it has.
- The greater the mass of a moving object, the more kinetic energy it has.
- Kinetic energy depends on both mass and velocity.
Potential Energy

- Potential Energy is stored energy.
  - Stored chemically in fuel, the nucleus of atom, and in foods.
  - Or stored because of the work done on it:
    - Stretching a rubber band.
    - Winding a watch.
    - Pulling back on a bow’s arrow.
    - Lifting a brick high in the air.
Gravitational Potential Energy

- Potential energy that is dependent on height is called gravitational potential energy.
Potential Energy

- Energy that is stored due to being stretched or compressed is called elastic potential energy.
Gravitational Potential Energy

- A waterfall, a suspension bridge, and a falling snowflake all have gravitational potential energy.
Gravitational Potential Energy

- “The bigger they are the harder they fall” is not just a saying. It’s true. Objects with more mass have greater G.P.E.
- The formula to find G.P.E. is G.P.E. = Weight X Height.
Kinetic-Potential Energy Conversion

Roller coasters work because of the energy that is built into the system. Initially, the cars are pulled mechanically up the tallest hill, giving them a great deal of potential energy. From that point, the conversion between potential and kinetic energy powers the cars throughout the entire ride.
At the point of maximum potential energy, the car has minimum kinetic energy.
Kinetic-Potential Energy Conversions

- As a basketball player throws the ball into the air, various energy conversions take place.
The Law of Conservation of Energy

- Energy can be neither created nor destroyed by ordinary means.
  - It can only be converted from one form to another.
  - If energy seems to disappear, then scientists look for it – leading to many important discoveries.
Law of Conservation of Energy

- In 1905, Albert Einstein said that mass and energy can be converted into each other.
- He showed that if matter is destroyed, energy is created, and if energy is destroyed mass is created. \( E = MC^2 \)
Vocabulary Words

- energy
- mechanical energy
- heat energy
- chemical energy
- electromagnetic energy
- nuclear energy
- kinetic energy
- potential energy
- gravitational potential energy
- energy conversion
- Law of Conservation of Energy
Heat Transfer: Conduction, Convection, and Radiation

Introduction

We have learned that heat is the energy that makes molecules move. Molecules with more heat energy move faster, and molecules with less heat energy move slower. We also learned that as molecules heat up and move faster, they spread apart and objects expand (get bigger). This is called thermal expansion.

Heat is always moving! If you have two objects or substances that are different temperatures, heat will always move **OUT** of the warmer object or substance, and **INTO** the cooler object or substance. This heat transfer will continue until the objects are the same temperature.

So how, exactly, does heat move out of one thing and into another thing? This is called heat transfer. (Remember, we learned that energy transfer is when energy moves from one thing or place to another, but the energy type stays the same). Heat can transfer (or move) in 3 ways: conduction, convection, and radiation. As you read about the three types of heat transfer, pay attention to:

- What the heat is moving through (solids, liquids and gases, or empty space)
- How the heat is being transferred (touch, currents, or waves)

Conduction

Last weekend, I went to the beach. I was walking barefoot on the soft, cool grass. When I got to the sand, I noticed that my feet were burning! Ouch! This is an example of conduction.
Conduction is how heat transfers through direct contact with objects that are touching. Any time that two objects or substances touch, the hotter object passes heat to the cooler object. (That hot sand passed the heat energy right into my poor feet!)

Think of a row of dominoes that are all lined up. When you push the first domino, it bumps into the second one, which bumps into the third one...all the way down the line. Heat conduction is like the dominoes. Imagine that you place one end of a metal pole into a fire. The molecules on the fire end will get hot. Each hot molecule will pass the heat along to the molecule next to it, which will pass the heat along to the next molecule, and so on. Before you know it, the heat has traveled all the way along the metal pole until it reaches your hand.

Some materials are better conductors than others. That’s because some materials are able to pass (conduct) heat more easily. Metals are great conductors. That’s why metal objects get hot so easily. Plastic and wood are poor conductors. They will still get hot, but it takes a lot longer for them to pass the heat from molecule to molecule.

Likewise, solids are better conductors than liquids or gases. That’s because solids have molecules that are very tightly packed together, so it’s much easier for the molecules to pass the heat along. The molecules in liquids and gases are spread further apart, so they aren’t touching as much. It takes longer for liquids and gases to conduct heat.

There are many examples of heat conduction. Any time two object touch, heat conduction will happen. Touching a hot iron is an example of conduction – the heat passes out of the iron and into your hand. So is holding an ice cube – the heat is conducted out of your hand, and into the ice cube (that’s why your hand feels cold). Cooking food on the stove is an example of conduction happening twice – the heat from the burner passes into the metal pan, and then the heat from the metal pan passes into the food, heating it up.
**Convection**

Convection is how heat passes through fluids. A fluid is anything that has loosely moving molecules that can move easily from one place to another. Liquids and gases are fluids.

One important property of fluids is that they rise when heated. That’s because the molecules spread out and move apart when they get hot. The hot fluid becomes less dense and rises up. Cooler fluid is less dense and so it sinks down. This up-and-down motion creates what are called convection currents. Convection currents are circular movements of heated fluids that help spread the heat.

Here’s an example. Last night I heated up soup for dinner. Yum! At first, the soup was cold in the pan. The soup at the bottom of the pan was closest to the hot stove burner, right? So the soup at the bottom heated up first. As it heated, the molecules spread apart and became less dense. So the heated soup rose up to the top.

As the hot soup rose up, the cooler soup at the top sank down to the bottom. When it was at the bottom, it was closest to the heat, so THAT soup got hot and rose up. As the soup continued heating, the hot soup rose and the cold soup sank. If you were to look closely, you would see the soup moving up and down in the pot. The up-and-down movement was a convection current. The convection current helped spread the heat around, until all of the soup was heated up.

Convection currents explain why the air is hotter at the top of a room and cooler at the bottom. Convection currents also explain why water is warm at the top of the ocean, but gets colder as you swim deeper.
One natural example of convection currents is wind. As the Sun shines down on an area of land, it heats the air above the ground. That warm air rises. As it rises, cooler air moves in to take the place at the bottom. This moving cooler air creates...wind! Wind happens all over Earth because Earth heats unevenly. There are always colder parts and warmer parts. The wind blows from the cooler parts of Earth to the warmer parts.

Other examples of convection are: boiling a pot of water on the stove; using a hot radiator to warm the air in a room; and using heated air to make a hot-air balloon rise up into the sky.

**Radiation**

So we’ve learned that conduction moves heat easiest through solids, and convection moves heat through liquids and gases. So how does the heat from the Sun get to Earth? There are no molecules in space! And how do you feel the heat from a campfire, even if you’re sitting several feet away?

The answer is radiation. Radiation is how heat moves through places where there are no molecules. Radiation is actually a form of electromagnetic energy. Remember we learned that electromagnetic energy moves in waves? Well, radiation is heat moving in waves. Radiation does NOT need molecules to pass the energy along.

All objects radiate heat, but some radiate much more heat than others. The biggest source of radiation is the Sun – it sends a HUGE amount of heat to Earth through electromagnetic waves. (Last weekend, at the beach, I could definitely feel the wonderful heat radiation from the Sun. I guess that’s why I got a sunburn. Oops! A little too much radiation!)
Light bulbs radiate heat. Try it! Hold your hand a few inches away from a light bulb. You can feel the heat, right? In fact, a good way to remember radiation is that it is how you can feel heat without touching it. Heat passes through the empty space until it reaches your hand. That’s radiation! A fire is another example of radiation. Even YOU are an example. Your body gives off heat! (That’s why a classroom gets warm when there are a lot of people sitting in it.)

**Review**

Remember – heat always passes from a warmer object to a cooler object until all objects are the same temperature.

Conduction is how heat travels between objects that are touching. Conduction travels fastest through solids, but liquids and gases can also conduct heat. Some materials, like metal, can conduct heat very quickly, while other materials (like plastic or wood) conduct heat very slowly.

Convection is how heat travels through fluids – liquids and gases. Hot fluids rise up, while cold fluids sink down. This up-and-down motion is called a convection current. Convection current spreads the heat in a circular, up-and-down pattern.

Radiation is how heat travels through empty space. Radiation does NOT require molecules to travel through. Any time you can feel heat without touching it, you are experiencing radiation.