CONCEPT 1

Energy can produce change in a system.

Activity

How Do *You* Describe Energy?

1. Think of an activity you are passionate about or interested in. What roles do energy play in it? For example, what forms does it take? What changes does it bring about? How does energy itself change? Record your ideas.
2. Discuss your ideas in small groups. Work together to come up with a description of what you think energy is.
3. Share and discuss your group's description with the class. Your teacher may add descriptions of energy from other sources as well.

What is **energy**? What does it do? How does it behave? Scientists have asked questions like these about energy for hundreds of years. Defining energy presents a problem, because it cannot be observed directly. Consider a scene like the one in **Figure 3. 1**. Energy is present in many forms. It's in the air, a walk down the street, and even in a conversation. But it cannot be seen.

Figure 3.1 Energy is all around you. **Analyzing: How is energy present in this image?**

Despite this limitation, scientists can investigate energy indirectly. They do so by observing the effects it has on other things. Over time, by inquiring about such effects, scientists began to develop an understanding of the properties of energy. They found that

- energy can cause change in a system.
- there are different forms of energy, with different characteristics.
- these forms of energy can be transferred or transformed.
- different physical quantities contribute to different forms of energy.

Energy and Systems

system anything that is under observation

surroundings anything that is not part of a system

Anything that is under observation can be referred to as a **system**. For example, the person and the bungee cord in **Figure 3.2** could be considered a system. Everything that is not part of this system—that is, everything else in the entire universe—is considered the **surroundings**. This idea can be expressed as an equation:

$$\text{universe} = \text{system} + \text{surroundings}$$

Notice that a system is something that we define. One person might define the system in **Figure 3.2** as the person jumping and the bungee cord. Someone else might define it as the person, the bungee cord, and the bridge that the cord is attached to. We define a system to help us study the system itself, as well as the parts of the surroundings that interact with it.

Energy produces change in a system. In the case of the person and the cord, the system is moving from a greater height to a lesser height. Energy may be added to the system from its surroundings or released from the system to its surroundings. For example, energy would be added to the system from its surroundings if wind pushed the person and the cord off the bridge. Similarly, energy is being released from the system to its surroundings as air resistance provides friction that slows the jumper down.

Figure 3.2 This person and cord above the Nanaimo River on Vancouver Island can be considered a system. **Inferring: What are the surroundings of this system?**

Activity

Dropper Popper Dilemma

A dropper popper is a special kind of half-ball. You will invert and release it from head height, waist height, and knee height.

1. Write a hypothesis to predict what you think will happen for each drop.
2. Test your hypothesis. How did it compare with your observations?
3. For each drop, identify the system you observed and its surroundings.
4. Discuss your observations and the following questions with your partner, and then with the class.
   a) What change(s) did you observe in the system?
   b) How was energy exchanged between the system and its surroundings?
   c) What other information about energy and its properties could help you explain your observations?

Before you leave this page . . .

1. a) Why can it be a challenge to observe energy directly?
   b) How can this challenge be overcome?
2. a) Describe a system that could be applied to your classroom.
   b) What makes up the surroundings of the system you defined?

CONCEPT 2

There are different forms of energy.

kinetic energy the energy of motion

potential energy the stored energy of an object as a result of its condition or its position

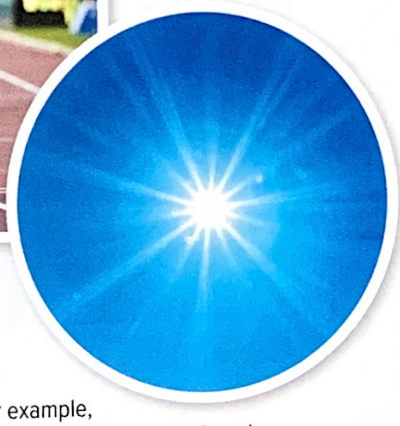
At the simplest level, energy may be classified into two main types: kinetic energy and potential energy. **Kinetic energy** is the energy of motion. Anything that is moving has kinetic energy. **Potential energy** is the stored energy an object has as a result of its condition or position. For example, the energy stored in the bonds of a chemical compound is a type of potential energy. So is the energy objects have due to their location relative to a reference point, such as the ground. The mountain bike and its rider in Figure 3.3 have kinetic energy because they are moving and potential energy because they are above the ground. The examples on the next page show different forms of kinetic energy. Examples of the forms of potential energy appear on the pages that follow.

Figure 3.3 This mountain bike and its rider have both kinetic energy due to their motion and potential energy due to their position. **Inferring: When will the mountain bike and its rider have the most kinetic energy? When will they have the most potential energy?**

Kinetic Energy

Mechanical Kinetic Energy

This is the energy of motion of objects that are larger than atoms and molecules. Any object that is moving has mechanical kinetic energy, from the smallest bacteria to the largest galaxies.



Radiant Energy

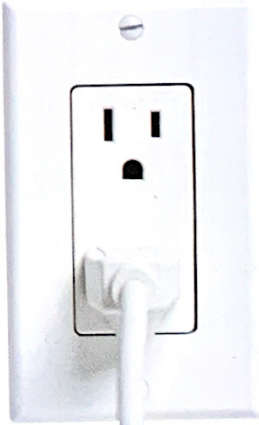
Radiant energy is the energy of electromagnetic waves that travel or "radiate" from an energy source. For example, light bulbs radiate ultraviolet radiation, visible light, and infrared radiation, which are transformed into thermal energy when they are absorbed by matter. The Sun radiates the entire electromagnetic spectrum. The energy of these waves is often called solar energy. Visible light is often called light energy.

Thermal Energy

This is the energy of the random motion of the particles that make up a substance. Particles of matter are always moving. However, the particles of warmer objects are moving faster than those of cooler objects. In common language, we use the word heat to mean the same thing as thermal energy. In science, however, heat and thermal energy are different. *Heat* is defined as thermal energy that is transferred from one object to another.

Electrical Kinetic Energy

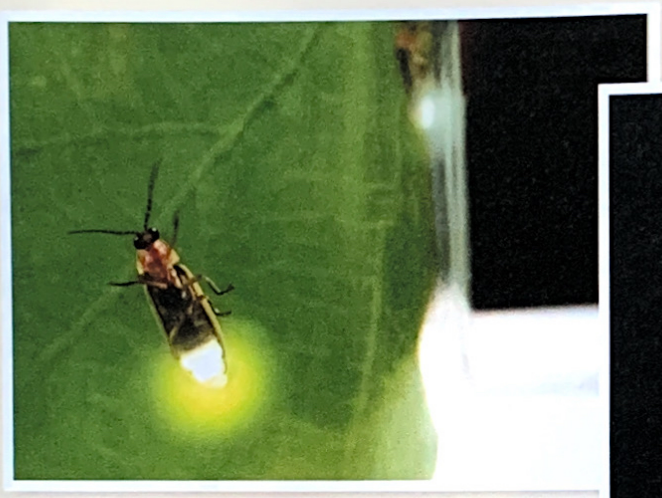
This is the energy of electrons moving along a wire or other conductor. A load (any electrical appliance) changes the electrical kinetic energy into another form, such as radiant energy. Lightning is also a form of electrical kinetic energy, where the air acts as the conductor.



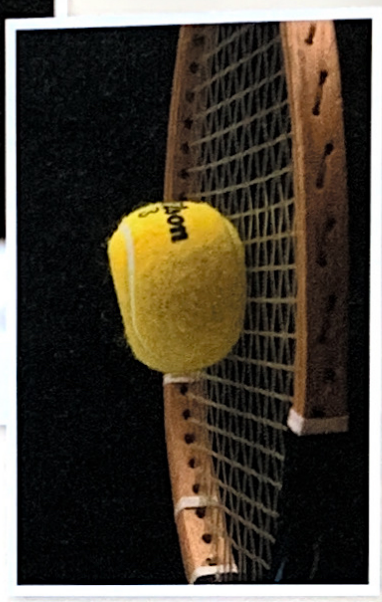
Sound Energy

Sound is the energy of vibrations or disturbances of the particles that make up matter. It travels through substances as a pressure wave. As the wave passes through a substance, its particles vibrate back and forth, colliding with nearby particles. In this way, sound energy travels away from its source.

Potential Energy



Chemical Potential Energy
This energy is stored in chemical bonds. Much of human society relies on the chemical potential energy stored in fossil fuels. Some animals, like the firefly shown here, transform chemical potential energy to produce light.



Elastic Potential Energy
This energy is stored in a stretched or compressed object. Elastic potential energy does not just apply to an elastic band or a spring. It applies to any object, like the soles of your shoes when you walk, or the tennis ball and racquet shown here.

Gravitational Potential Energy
This energy is due to the position of an object relative to a reference point, such as the ground. A roller coaster at the top of a large hill has more gravitational potential energy than it does at the bottom. This change results in a hair-raising ride.

Nuclear Energy
This energy is stored within the nucleus of an atom. Nuclear processes can release an enormous amount of energy. Topic 3.2 explores nuclear energy further.

Electrical Potential Energy
This energy is stored by a separation of positive and negative charges, as it is in a cell or battery.

Magnetic Potential Energy
A compass needle moves because it's magnetic and is attracted by Earth's magnetic field. If you prevent the needle from moving, it has magnetic potential energy, as it now has the potential to move.

Activity

Energy Stations

Visit the different energy stations set up around the room, as per your teacher's instructions. At each station, follow the instructions provided. Then identify the type(s) of energy demonstrated at each station.

Before you leave this page . . .

1. Use a Venn diagram to compare kinetic and potential energy.
2. Give one example of each of the following:
   a) a form of kinetic energy
   b) a form of potential energy
   c) a form of energy that has both kinetic and potential energy