Reflect

Have you ever launched a model rocket? Can you describe the motion of the rocket? Where does the rocket get its energy to launch?

The Energy of Motion

Kinetic energy is the energy of motion. Only matter in motion has kinetic energy. Kinetic energy depends on an object's mass and velocity. The faster something is moving and/or the more massive it is, the more kinetic energy it has. The model rocket launch pictured on the right is not as big as the Apollo rocket that carried astronauts to the Moon, so it has only a tiny fraction of the kinetic energy that sent that multi-stage, multi-ton rocket to the Moon. That energy came from burning fuel. In the model rocket, a tiny chemical engine cartridge stores chemical **potential energy.** When it is ignited, the combustion releases kinetic energy of exhaust gases that provides the thrust to lift the rocket. In the Saturn V rockets that launched the Apollo program, huge external fuel tanks and multiple engines converted potential energy into tremendous kinetic energy that sent the rocket out of Earth's orbit and to the Moon.

kinetic energy: energy of motion

potential energy: stored energy

Energy can be classified as potential or kinetic.

There are two main forms of energy in a system: potential and kinetic. **Potential energy** (PE) is stored energy. **Kinetic energy** (KE) is energy in the form of motion. Kinetic energy is motion of waves, electrons, atoms, molecules, substances, and objects. The motion can be large, such as celestial bodies, moving organisms, objects, machines, wind, waves, and sound, or small, such as heated particles, the flow of charges, and changing electrical and magnetic fields. The total amount of potential energy and kinetic energy in a system is known as **mechanical energy.**

Sitting on a launch pad, a rocket just represents chemical potential energy. When the engines are ignited, the rocket will either go into a circular orbit or fall back to Earth. What happens depends on if there is enough fuel to provide enough kinetic energy to escape Earth's gravity. In order for the rocket to go beyond Earth, as did the Cassini Mission to Saturn, there must be sufficient fuel stored as potential energy to be transformed into enough kinetic energy to reach escape velocity. Often that takes multi-stage rockets and tons of fuel to boost a satellite or spacecraft into the correct trajectory.

Conservation of Energy

During a rocket launch, you can see light from the hot flames shooting out the exhaust. You can hear the roar of the engines straining to lift the massive rocket. And you can see the rocket move upward. The chemical potential energy of the fuel was transferred not only to kinetic energy of a moving rocket, but also to the heat and light of the exhaust flames, and to the sound energy heard during the powerful launch. So energy is never created nor destroyed, but does change form. When potential energy in the fuel changed into kinetic energy, a small portion of that was converted into heat, light, and sound energy.

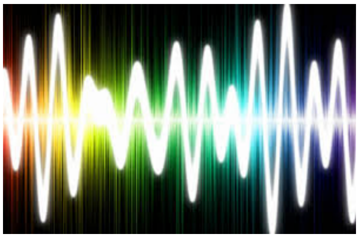
Reflect

There are different types of kinetic energy.

- **Radiant energy** is electromagnetic energy that travels as waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Sunshine is radiant energy that converts to the energy and warmth that make life on Earth possible.

- **Thermal energy** is the vibrating movement of the atoms and molecules within substances. Heating an object causes its atoms and molecules to move faster and collide. Electrical energy is converted into thermal energy by devices like ranges, toasters, dryers, and heat lamps.

- **Motion energy** is also called mechanical energy and is the movement of objects. It takes energy to get an object moving. Energy is released when an object slows down. Examples of motion energy are moving baseball, wind, and waves. An alternative definition for energy is the work done by a force acting through a distance. Work is measured in newton-meters, called joules (J). If the force does not move the body, no work is done. Standing still may seem like work, but since no physical work over a distance is done, no work is done. The context is important in physics, especially when mechanical energy refers to the sum of the potential and kinetic energy in a system.



- **Sound energy** is the movement of energy in longitudinal (compression/expansion) waves through substances. Sound is produced when a force causes an object or material to vibrate. The energy is transferred through the substance in a wave.

- **Electrical energy** is typically flow of tiny charged particles moving through a wire, such as a light bulb. Electrical energy often transferred to mechanical energy in power tools, fans, lawn mowers, etc. Lightning is an example of unconfined electrical energy in nature.

Look Out!

Essentially, kinetic energy is the energy of motion. As you move faster, your kinetic energy increases. As you add more mass, the kinetic energy also increases. However, speed and mass do not affect kinetic energy in exactly the same way. Observe:

An object's kinetic energy (KE) depends on:
- the object's **mass *m*** (kinetic energy is directly proportional to the object's mass) and
- the object's **speed *v*** (kinetic energy is directly proportional to the square of the object's speed)

$$KE = \frac{1}{2} m v^2$$

The Unit of Joule (J)

Scientists measure both potential energy and kinetic energy in joules (J). A joule describes the amount of energy needed to do a certain amount of work or cause a certain amount of change. One joule is equal to the energy transferred (or work done) to an object when a force of one newton acts on that object in the direction of its motion through a distance of one meter (one newton-meter). More joules of energy can perform more work or cause more change. Scientists are able to use the same unit to measure both types of energy because kinetic energy and potential energy are related. Remember, a system's mechanical energy equals its potential energy plus its kinetic energy.

What Do You Think?

The runner below has a mass of 55 kilograms and is moving at 3.87 meters per second. What is his kinetic energy?

$$KE = \frac{1}{2} m v^2$$

$$KE = 0.5 \times 55 \times (3.87)^2$$

$$= 0.5 \times 55 \times 14.9769$$

$$= 411.86 \text{ J}$$

Try Now

Your turn!

Use what you know to complete the practice problems below.

1. What is the kinetic energy of a 150 kilogram object that is moving at a speed of 15 meters per second?

2. An object has a kinetic energy of 25 joules and a mass of 34 kilograms. How fast is the object moving?

3. An object moving with a speed of 35 meters per second has a kinetic energy of 1500 joules. What is the mass of the object?

4. What is the kinetic energy of a 1200 kilogram object that is moving at a speed of 24 meters per second?

5. An object has a kinetic energy of 14 joules and a mass of 17 kilograms. How fast is the object moving?

Connecting With Your Child

Egg Drop Experiment

This can be a messy experiment but a fun way to see how gravitational potential energy is converted to kinetic energy. As a family, you will design a compartment that can safely protect an egg from breaking when you drop it from a height of several meters. You may want to perform this experiment outdoors. Be careful when dropping the eggs. Make sure you are standing on a sturdy foundation so that you will not slip or fall.

You may construct your compartments from a wide variety of materials, including egg cartons, milk cartons, cereal boxes, newspapers, and bubble wrap. You will also need eggs and a meter stick or tape measure.

You may need to test many different designs (and break many different eggs!) before you design a compartment that successfully protects an egg. Record which designs and materials have the most success. Suggest possible explanations why certain materials were most successful in protecting an egg. Have your child explain when the potential energy and kinetic energy were the highest and lowest during each test.

After completing the experiment, you can discuss how these concepts may apply to other areas in life. For example, you could consider designing cars to safely withstand a crash or sneakers to cushion a runner's feet.

Here are some questions to discuss with your child:

- Which materials were the most successful in protecting an egg? Why do you think so?
- Did you use friction or air resistance to your advantage in your design?
- How do you think engineers use models and tests similar to this activity when they design safety features for cars? What would be the advantages of using models instead of actual cars?
- Can you apply what you learned in this activity to other areas of your life?