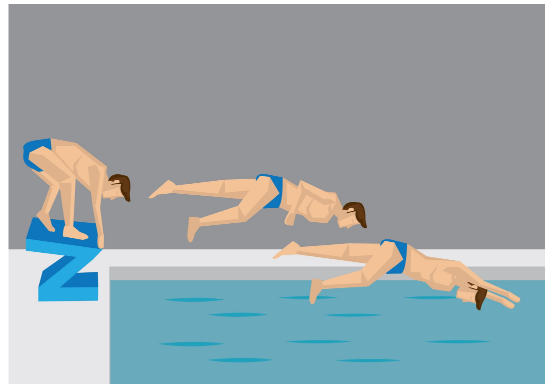
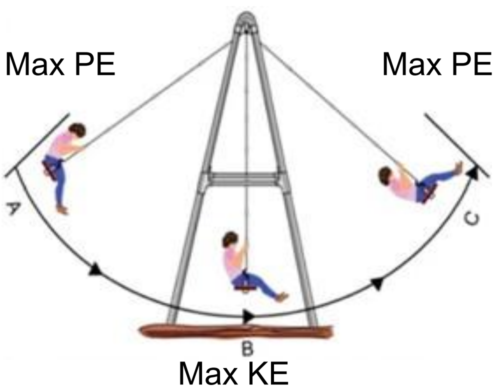
Reflect

Have you watched divers in competition? Which diver position on the right demonstrates kinetic energy (energy in motion)? Which diver position shows potential energy (stored energy)?



The diver on the diving board is not an example of kinetic energy. He is still and not moving, but he does have stored energy (potential energy). He will soon release that stored energy to become kinetic energy in the next two positions as he dives off the board and into the water.

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. Look at the picture of a person swinging below. The diagram shows how the swing moves back and forth as the person rides it. When the person swings all the way back (position A), the swing pauses a moment. At this moment, the swing has only potential energy. The swing then falls forward, gradually gaining speed. As it falls, its potential energy changes to kinetic energy.



At position B, the swing has only kinetic energy. As the swing continues forward, it gradually slows down. Its kinetic energy changes back to potential energy until it reaches the farthest point in its arc (position C). Here the swing pauses again for a moment. At this moment, the swing has only potential energy. It then falls backward through its arc. Its potential energy changes to kinetic energy, and the cycle is repeated.

Energy can change within a system.
Energy can take many forms, such as mechanical energy, sound energy, thermal energy, etc. What do these forms have in common? They all have the ability to cause changes to a system (a set of connected things that work together). As you swing on the playground, you and the swing form a system. The increase or decrease of different forms of energy in a system has a direct effect upon the system’s physical variables.

These variables include temperature, speed, position, pressure, and motion. If someone turns on a stove burner under a pot of water, energy from the burner will cause the pot to heat up. The heat will cause the water to come to a boil. This shows the relationship between energy and the system of the water-filled pot.

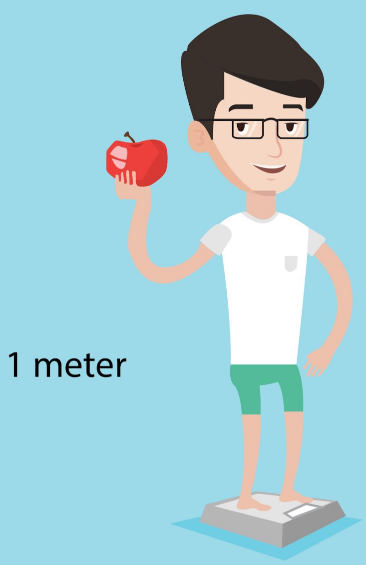
Look Out!

As air particles collide with the parachute, the force of air resistance slows down the skydiver.

Consider the parachute jumper pictured on the right. While he was poised at the open doorway before he jumped out of the plane, he had maximum potential energy. You may think that his potential energy was destroyed and kinetic energy was created when he jumped out of the plane and as he fell. In fact, the energy only changed forms. Energy cannot be created or destroyed. This is called the *law of conservation of energy*. As any object falls, it gets faster and faster as potential energy is transformed into kinetic.

When the skydiver deploys his parachute, it interacts with a large area of particles in the air. These particles are tiny, but there are a lot of them. As the chute collides with the air particles, the upward force of the particles on the chute causes some of your kinetic energy to transform into heat in the air particles. This force is a type of friction called *air resistance*. It gradually slows the skydiver to a safe speed so that he or she will not be injured when landing.

Kinetic energy is the energy of objects in motion. Kinetic energy is proportional to the mass of the moving object and grows with the square of its speed. Scientists measure both potential energy and kinetic energy in joules (J). 1 joule (J) = 1 kg x m^2/s^2 A joule describes the amount of energy needed to do a certain amount of work or cause a certain amount of change. 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 total energy equals its potential energy plus its kinetic energy.

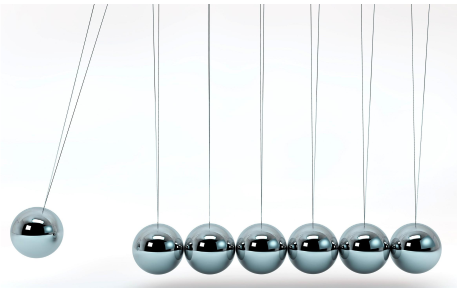


A joule is the unit of measurement for energy.

1 joule is the amount of energy needed to apply a force of 1 newton over 1 meter.

1 joule is equivalent to the energy needed to raise a medium apple (100 g) up 1 meter.

When the motion energy of an object changes, there is inevitably some other change in energy at the same time. This means that energy can transfer to another object or to the surroundings. A Newton's cradle is a good example of the law of conservation of energy, which states that energy can be neither created nor destroyed, only transferred from one form or object to another. When the first ball strikes the second ball and stops, you may think its kinetic energy is destroyed; however, it is actually transferred to the second ball, which then transfers its kinetic energy to the third ball, and so on. This is why the last ball bounces up and the chain reaction flows back and forth as energy is conserved.



What Do You Think?

What do you think happens to the kinetic energy of a moving car that slows down and stops?

Sometimes energy can change forms, such as when a car hits its brakes. When a car begins to slow down, its kinetic energy decreases until it stops, when its kinetic energy reaches zero. All of this energy didn't just disappear, however. The car's kinetic energy changed into other forms of energy, such as heat, light, and sound.

Conservation of Energy in Systems

Remember, the law of conservation of energy states that energy can be neither created nor destroyed, only transferred from one form or object to another. This means that for a given system, the total energy of the system never changes.

Imagine a system consisting of a bowling ball, a bowling lane, and bowling pins. First, the bowling ball rolls down the lane with an amount of kinetic energy. The lane and pins do not have any energy, because they are stationary. As the ball rolls, friction with the lane slows it down. The ball, in turn, transfers heat energy from the friction to the lane. The bowling ball slows down more when it hits the pins. That contact transferred some of the ball's kinetic energy to the toppled pins. What the bowling ball lost in kinetic energy was gained by the lane and the pins. Do you think there is more or less energy in the total system?

Look Out!

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. Speed and mass do not affect kinetic energy in exactly the same way.

An object's kinetic energy depends on:

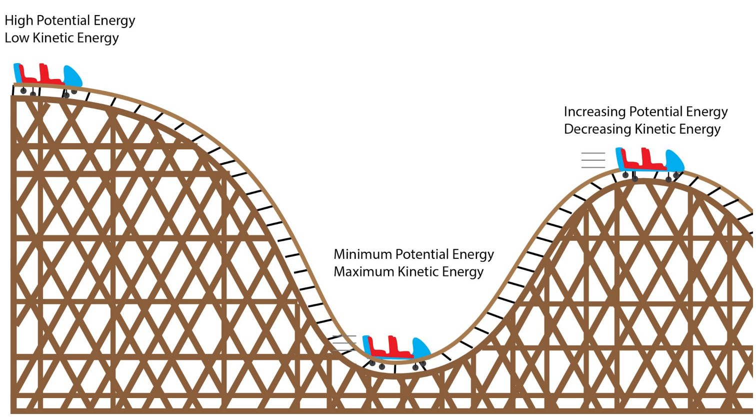
- the object's **mass** (kinetic energy is *directly proportional* to the object's mass), and
- the object's **speed** (kinetic energy is *directly proportional* to the *square* of the object's speed).

What Do You Think?

Everyday Life: Energy and Roller Coasters

Check out the picture of the roller coaster below. Why does the kinetic energy change? Is it the mass or the speed that causes the change?

Mechanical energy is part of everyday life. Have you ever ridden a roller coaster at an amusement park? Engineers who design roller coasters must understand the relationship between potential and kinetic energy. For example, engineers take advantage of potential energy when the coaster car is at the top of the roller coaster's first hill. This is usually the highest point on the coaster; therefore, a car at this point has the greatest potential energy. As the coaster car rolls down the hill, its potential energy is converted to kinetic energy. At the bottom of this hill, the car's velocity is very high because it has a lot of kinetic energy, which propels the car up the next hill. As the car climbs this hill, its kinetic energy decreases, because it slows down.



Try Now

Four objects are travelling with a velocity of 2 m/s. Data about their masses and kinetic energy are found below. Examine the table and answer the questions that follow.

Object	Mass (kg)	Kinetic Energy (J)
A	5 kg	10 J
B	10 kg	20 J
C	15 kg	30 J
D	20 kg	40 J

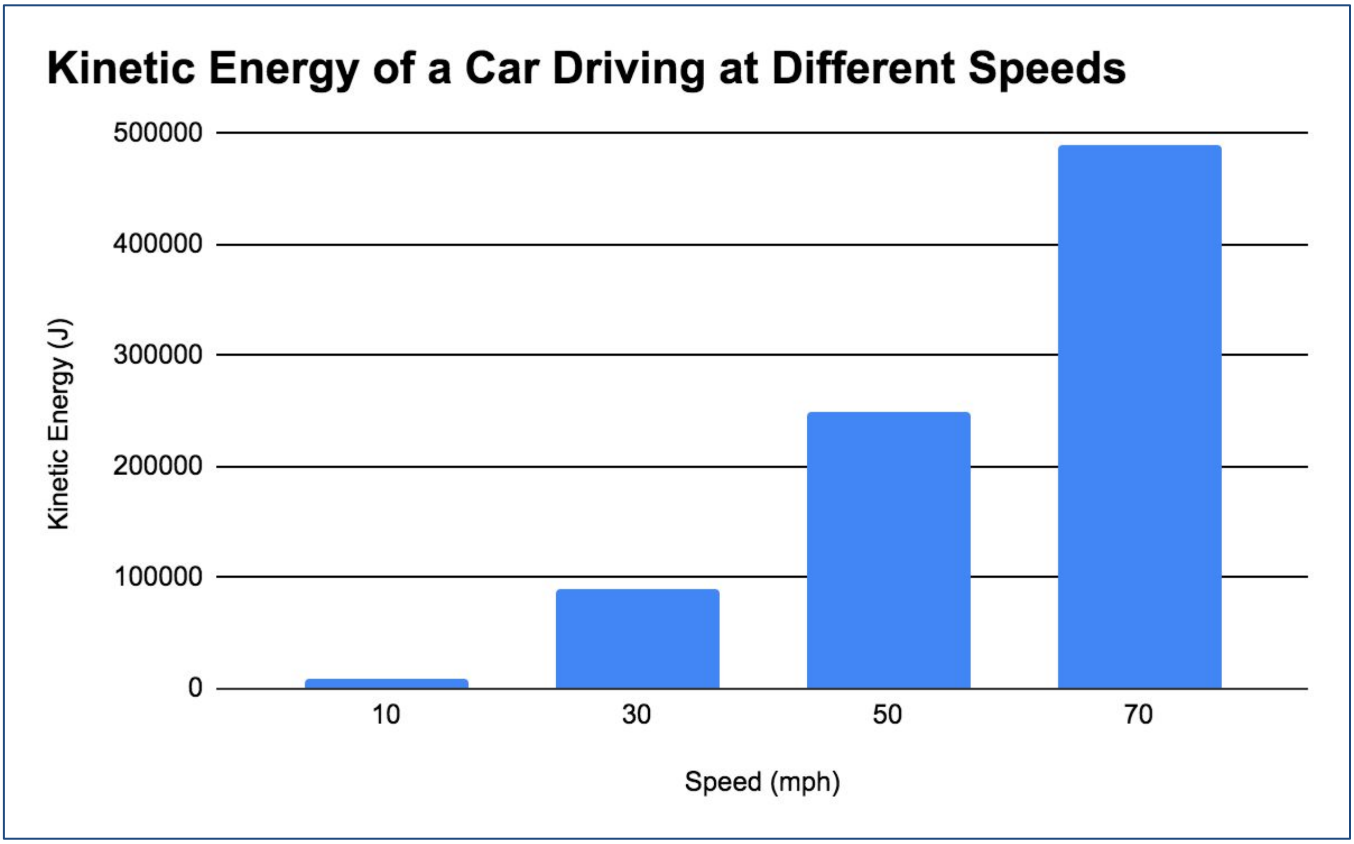
As mass increases, what happens to the kinetic energy?

Is the mass-kinetic energy relationship directly proportional (as one variable increases, the other increases) or inversely proportional (as one variable increases, the other decreases)?

If a person throws a wiffle ball and a tennis ball with the same speed, which object would travel with more kinetic energy? Justify your selection.

A small pebble and one large boulder start at the same height and begin rolling down the side of a mountain. Which object would have less kinetic energy as it crashes on the road at the bottom of the mountain? Justify your selection.

Examine the graph below and answer the questions that follow.



Describe the relationship between speed and kinetic energy.

Is the speed-kinetic energy relationship directly proportional (as one variable increases, the other increases) or inversely proportional (as one variable increases, the other decreases)?

Use your knowledge of kinetic energy to explain why high-speed car crashes are more dangerous than low-speed car crashes.