How Are Energy and Motion Related?

What does a rock falling into water have to do with energy? You will learn how scientists use the word *energy* to describe an ability to move or cause...
change. All objects have energy, and energy can even be passed from one object to another. Different factors, like weight and speed, can affect an object's energy.

1. Moving Objects Have Energy

When you use the word energy, you might say, “I don't have much energy today. I can't get out of bed!” A scientist will agree that it does take energy to move your body out of bed. But what is energy?

When a rock is thrown into water, the person’s moving arm transfers energy to the rock. The moving rock then transfers energy to the water, which makes it splash.

In science, energy is the ability to make an object move or to cause a change. All moving objects
have energy, which is called energy of motion. A basketball has energy when it bounces on a court. Water has energy as it flows in a river, and air has energy when it blows by as wind.

How does an object get its energy of motion? One way is when a moving object \textit{transfers} its energy to another object. To \textit{transfer} means to shift or to move from one object to another. Suppose you have a rock in your hand. When you throw the rock, you transfer energy from your moving arm to the rock. Your moving arm is the source of the rock's energy. When the moving rock lands in a pond, it makes a splash because the rock's energy is transferred to the water. The drops of pond water that make up the splash are now flying through the air. Their energy came from the energy of the rock.

2. Heavier Objects Have More Energy

You just learned that all moving objects have energy. But not all moving objects have the same amount of energy. One factor that affects the amount of energy that a moving object has is weight.
A large rock is heavier and has more energy than a small rock that is moving at the same speed. The rock that weighs more makes a bigger splash. This is because the heavier rock transfers more energy to the water.

A heavier object has more energy than a lighter object that is moving at the same speed. Suppose that you have two rocks and that one rock is much larger than the other. The larger rock is also much heavier than the smaller rock. If you dropped them into a pond from the same height, they would land in the water at the same time since they have the same speed. But even though their motion is the same, they have different amounts of energy. You can see this difference in energy because the larger rock would cause a much bigger splash than the smaller rock. The heavier rock makes a bigger splash because it transfers more energy to the water.

Another example is if a bowling ball and a soccer ball are rolling at the same speed. Both are about
the same size and shape. But the bowling ball is much heavier. Even though it moves at the same speed as the soccer ball, it has much more energy. You would not want the bowling ball to run into your foot! It has more energy to transfer to your foot and cause pain.

3. Objects Moving Faster Have More Energy

Suppose you are playing baseball with your friends. One ball moves slowly, and your hand only moves a little when you catch it. But another ball moves much faster, and when you catch it, your hand moves back a lot. Both balls move your hand because they transfer energy. Why did the fast-moving ball transfer more?
The more speed an object has, the more energy it has and transfers. This is why a slow-moving rock creates a much smaller splash when it hits the water than a fast-moving rock does.

Speed is another factor that affects how much energy of motion an object has. Picture a golf ball slowly rolling toward your bare foot. If it hits you, you would hardly feel it. Now picture that same ball moving very fast when it hits your foot. This time, it would hurt more because as an object moves faster, its energy of motion increases. This is why the fast-moving baseball made your hand move more than the slow-moving baseball.

Another example of how speed affects energy of motion is if you throw a rock twice into a pond from the same height but at different speeds. First, you might throw the rock very slowly. It would make a small splash when it hits the water. But if you throw the same rock much faster, it would make a much bigger splash. This is because the rock travels at a greater speed when it hits the water, so it has more
energy. So, it transfers more energy to the water, which makes a bigger splash.

4. Energy Can Be Gained and Lost

You now know that objects can transfer their energy to other objects. But what happens to the energy of the moving object after it is transferred?

An object's energy does not just appear and disappear. It must come from somewhere, and it must go somewhere. So, objects can gain and lose energy.

When this rock is thrown, it gains speed and energy. When it hits the water, it has less speed and its energy is transferred to the water. So, it loses energy when it hits the water.
Recall that when you throw a rock into a pond, it has energy of motion, but the rock's energy does not just appear out of nowhere. It comes from the energy of your moving hand. When you throw the rock, your moving hand transfers energy to the rock. When this happens, the rock has more energy than it did before, and your hand has less energy.

When the thrown rock hits the water, most of its energy is transferred to the water when it pushes the water up in a splash. At the same time, the rock slows down as it enters the water. Because the rock's speed decreases, it has less energy. Eventually, the rock sinks to the bottom of the pond. At the bottom of the pond, the rock is no longer in motion. It no longer has energy of motion because it has all been transferred to the water.

5. Energy Can Be Stored

You learned that a moving object has energy of motion. But can a still object have energy, too?

A still object can also have energy. Instead of having energy of motion, it has stored energy. Any object that is lifted off the ground has stored energy since gravity is pulling on it. These objects have the potential, or ability, to move or cause a change without another object touching it. If you
drop the object, gravity will make it fall. You do not have to transfer energy to the object for it to move.

An object on the ground can also have stored energy, depending on its position. For example, when you stand in your room, you have the potential to fall over even though you are on the ground. But if you lie flat on the floor, you do not have stored energy since you cannot change positions without moving yourself.

Stored energy can be transferred. A rock you hold has stored energy. If you let go of it, its stored energy changes into energy of motion as it falls. When the rock hits the ground and stops moving, it has lost all of its energy of motion. It has also lost its stored energy. The energy has been transferred...
to the floor and other nearby objects.

6. Energy Is Conserved

Objects can gain and lose stored energy, just like how they can gain and lose energy of motion.

Energy moves from object to object, but no matter what, the total energy always stays the same. So, for example, when you throw a rock into a pond, the amount of energy that the rock loses is equal to the energy gained by the water and air around it. Or the energy of motion can become stored energy. But no amount of energy is created from nothing and no amount of energy is destroyed. The total amount of energy stays the same before and after each change in motion.

Energy cannot be created or destroyed, which means that when energy is transferred, the total amount of energy always stays the same. So, scientists say that energy is conserved.
Because energy cannot be created or destroyed, scientists say that energy is *conserved*. *Conserved* means having the same total amount before and after a change happens. Another way of saying that energy is conserved is to say that energy cannot be created or destroyed. It can only transfer from one object to another during a change or become stored energy. For instance, suppose you kick a ball up a small hill. The ball has energy of motion as it rolls up the hill. As it rolls up the hill, most of its energy of motion becomes stored energy since the ball slows down and has the potential to roll down the hill. In this interaction, like all interactions, the energy is conserved.

**LESSON SUMMARY**

How Are Energy and Motion Related?

1. Moving Objects Have Energy

   Energy is the ability to make an object move or cause change.
All moving objects have energy of motion. An object can get energy when one moving object transfers its energy to another object.

2. Heavier Objects Have More Energy
If you drop two different-sized rocks into water, the heavier one will create a bigger splash. It has more energy. Heavier objects have more energy than lighter objects moving at the same speed.
3. Objects Moving Faster Have More Energy
As objects move faster, the amount of energy they have increases. If you drop a rock into water twice at different speeds, the faster-moving one will create a bigger splash.

4. Energy Can Be Gained and Lost
An object's energy can be gained or lost. When an object transfers energy to another object, it loses that energy. But that energy does not simply disappear. The other object gains that energy.
5. Energy Can Be Stored

Moving objects are not the only objects that have energy. Still objects can have energy that is called stored energy. Any object that is lifted off the ground has stored energy because gravity is pulling on it.

6. Energy Is Conserved

All objects can gain and lose energy through an energy transfer. When energy transfers to another object, the amount of energy stays the same because energy is...
You hear the riders scream as the roller coaster train races around the track! The train speeds up and gains energy as it goes down a hill. How does energy make a roller coaster more exciting?

You see it in the distance as you walk across the hot pavement to get in line. The track loops through the air, and the towering hill looks several stories tall. Are you really going to ride that monster of a roller coaster?

You start to feel scared. Your stomach hurts. Finally, you are at the front of the line. You still have time to change your mind, and you wonder if maybe you should run away! Then you see that the people who just finished their ride are smiling. Well, most of them are smiling.

You sit down in your seat and pull down your
harness. A worker comes by to make sure you are locked in. Then the roller coaster slowly begins to pull out. There is no turning back now!

You see the sky as the roller coaster train slowly climbs up a steep hill. You hear the clink of the chains that are pulling the train, transferring energy to it as it moves up the hill. As the train climbs, it gains stored energy. What will happen to all this energy?

The slow ride up the first hill may be the least exciting part of the roller coaster ride. But it is the most important. Roller coaster trains do not have engines to move them around the track. Instead, the train uses the stored energy that the train gets as it climbs the first hill. This is what allows the train to speed through the rest of the ride. The stored energy will change into the train's energy of motion as the train goes downhill.

Once you reach the top of that first hill, the train is at a slow crawl. Most of its energy is stored energy. Then gravity begins to pull the train downhill. Its stored energy starts changing into energy of motion. Whoa! You let out a scream as the train
goes faster and faster. Its energy of motion increases. It might be moving more than 80 kilometers per hour (about 50 miles per hour) when you reach the bottom of the hill. Now, most of the stored energy that the train had at the top of the hill has changed into the energy of motion.

Roller coaster engineers know that if a roller coaster started on a small hill, it would be a boring ride. The first hill needs to be tall enough to give the train enough stored energy to make it all the way around the track. And to make it around with speed! So, the first hill is usually the tallest in the whole ride.

Through the Loop

Your heart is racing as the train speeds around the track. The train slows a little as a small hill causes some of its energy of motion to change back into stored energy. But it quickly changes back to energy of motion as the train speeds down the small hill.
The roller coaster goes through twists and turns, which makes your stomach turn. Is the train going to fall? You don't have to worry. Roller coaster engineers designed trains that have three sets of wheels. Every car has wheels that sit on the top, bottom, and side of the track to keep it moving smoothly along. Thank goodness, because the track forms a loop and you are about to be turned upside down!

As you zoom toward the top of the loop, your speed decreases. Some of your energy of motion once again changes into stored energy. This stored energy changes back into energy of motion as you zip down the other side of the loop. Of course, all of this happens so fast, you do not have time to think about energy changes.

**Losing Steam**

As you race around the hills, loops, and curves of the track, the train's energy is constantly changing. You speed up when stored energy changes to the energy of motion. You slow down when energy of motion changes to stored energy. But you also slow down little by little all along the way. Some of the train's energy is lost, or transferred, when the wheels rub against the track. Some of the energy is also transferred to the air. These transfers make the train lose energy. The roller coaster train is always losing some of its energy. Yet, the overall energy is always conserved.
Engineers design roller coasters so that you are moving the slowest at the end of the ride. But the train needs to lose even more energy to stop. Roller coaster engineers add brakes that can quickly stop the train. The brakes are actually part of the tracks at the end of the ride. The energy of the train is transferred to the brakes as they clamp down on the side of the train.

The train stops right at the platform. Its energy of motion is finally zero. Your harness unlocks. You hop out of the train and run back into line. You want to experience the energy transfers of a roller coaster again!