SUPERCHARGED SCIENCE

Unit 5: Energy (Part 2)

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Appropriate for Grades:
Lesson 1 (K-12), Lesson 2 (K-12)
Duration: 6-15 hours, depending on how many activities you do!

We covered some confusing stuff in the previous unit, but don't feel bad if you're having trouble with it. It takes a while for this to sink in. In Unit 5, we're going to talk about the two main categories of energy—potential and kinetic. We will talk about transfer of energy, and discuss conservation of energy and energy efficiency.

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Key Vocabulary

Conservation of Energy means that in a closed system, energy can be neither created nor destroyed.

Energy is the ability to do work. Energy can be transferred. In other words, it can be changed from one form to another and from one object to another.

Energy efficiency is how much energy in a system is transferred to useless energy. The most common forms of useless energy are sound energy and heat energy.

Force is a push or a pull, like pulling a wagon or pushing a car.

Gravitational potential energy is the amount of energy something has due to its height above the ground. The higher it is and the more mass it has, the more gravitational potential energy it has. This can be expressed through the equation PE = mgh.

Kinetic energy is the energy of motion. The faster something is moving and/or the more massive it is the more kinetic energy it has. This can be expressed through the equation $KE=1/2\ mv^2$.

Mechanical advantage is simply how many times easier it is to lift an object using a simple machine. Officially, mechanical advantage is the factor by which a mechanism multiplies the force put into it. A simple machine with a mechanical advantage of 100 could lift a 100 pound load with the effort of one pound.

Potential Energy is the amount of energy something can use to do work.

Power measures how quickly work can be done. Mathematically, power is work divided by time. Power can be measured in horsepower or Watts.

Pulleys, like all simple machines, sacrifice distance for force. The greater the distance the effort moves, the less force is needed to lift the load. The **pulley** is a very powerful **simple machine**.

Simple machines give you mechanical advantage. A major job of simple machines is to decrease the force needed to move something. The more pulleys that are rigged together, the more effective a pulley system can be.

Work is moving something against a force over a distance. Mathematically, work = force x distance. Work can be measured in Joules or calories.

Unit Description

In Part 1, we began our journey to understanding energy. We discussed the fact that energy is the ability to do work. We defined work as moving an object over a distance against a force. We defined power as the amount of work done over time. We also defined a few of the common energy units—Joule, calorie, horsepower, and Watt.

We covered some confusing stuff in the previous unit, but don't feel bad if you're having trouble with it. It takes a while for this to sink in. In Unit 5, we're going to talk about the two main categories of energy—potential and kinetic. We will talk about transfer of energy, and discuss conservation of energy and energy efficiency.

Objectives

Lesson 1: Potential Energy

All the different forms of energy (heat, electrical, nuclear, sound, etc.) can be broken down into two categories—potential and kinetic energy.

Think of potential energy as the "could" energy. The battery "could" power the flashlight. The light "could" turn on. I "could" make a sound. That ball "could" fall off the wall. That candy bar "could" give me energy. Potential energy is the energy that something has that can be released. For example, the battery has the potential energy to light the bulb of the flashlight if the flashlight were to be turned on and the energy were to be released from the battery. Your legs have the potential energy to make you hop up and down if you want to release that energy (like you do whenever it's time to do science!). The fuel in a gas tank has the potential energy to make the car move.

Highlights

- Potential energy is the amount of energy something can use to do work.
- Gravitational potential energy is the amount of energy something has due to its height above the ground. The higher it is and more mass it has, the more gravitational potential energy it has. We can express this mathematically as PE = mgh.
- Energy can be transferred. In other words, it can be changed from one form to another and move from one object to another.
- Conservation of energy means that in a closed system energy can be neither created nor destroyed.
- Energy efficiency is how much energy in a system is transferred to useless energy. The most common forms of useless energy are sound energy and heat energy.

Objectives

Lesson 2: Kinetic Energy

Kinetic energy is the energy of motion. Kinetic energy is an expression of the fact that a moving object can do work on anything it hits. It describes the amount of work the object could do as a result of its motion.

Whether something is zooming, racing, spinning, rotating, speeding, flying, or diving, if it's moving, it has kinetic energy. How much energy it has depends on two important things—how fast it's going and how much it weighs. A bowling ball cruising at 100 mph has a *lot* more kinetic energy than a cotton ball moving at the same speed.

Let's recap the highlights for kinetic as well as potential energy so you can see how they are related.

Highlights

- Potential Energy is the amount of energy something can use to do work.
- Gravitational potential energy is the amount of energy something has due to its height above the ground. The higher it is and more mass it has, the more gravitational potential energy it has. Mathematically this is expressed as PE = mgh.
- Kinetic energy is energy of motion. The faster something is moving and/or the more massive it is, the more kinetic energy it has. Mathematically this is expressed as KE = 1/2 mv^2.
- Energy can be transferred. In other words, it can be changed from one form to another and move from one object to another.
- Conservation of energy means that in a closed system energy can be neither created nor destroyed.
- Energy efficiency is how much energy in a system is transferred to useless energy. The most common forms of useless energy are sound energy and heat energy.

Textbook Reading

This is the second unit on energy. In Unit 4, we discussed the fact that energy is the ability to do work.

We defined work as moving an object over a distance against a force. We defined power as the amount of work done over time. We covered some confusing stuff, but don't feel bad if you're having trouble with it. It takes a while for this to sink in.

In this lesson, we're going to talk about the two main categories of energy—potential and kinetic. We will talk about the transfer and conservation, and energy efficiency.

Potential Energy

All the different forms of energy (heat, electrical, nuclear, sound, etc.) can be broken down into two categories—potential and kinetic energy.

My students have nicknamed potential energy the "could" energy. The battery "could" power the flashlight. The light "could" turn on. I "could" make a sound. That ball "could" fall off the wall. That candy bar "could" give me energy.

Potential energy is the energy that something has that can be released. For example, the battery has the potential energy to light the bulb of the flashlight if the flashlight is turned on and the energy is released from the battery. Your legs have the potential energy to make you hop up and down if you want to release that energy (like you do whenever it's time to do science!). The fuel in a gas tank has the potential energy to make the car move.

Kinetic Energy

Kinetic energy is the energy of motion, or an expression of the fact that a moving object can do work on anything it hits; it describes the amount of work the object could do as a result of its motion.

Let's try to put that a little more simply. Remember from the last unit that work is the amount of distance something travels against a force. A Joule is the amount of energy it takes to exert one Newton the distance of a meter. Also, remember that a Newton is a unit of force. It takes about one Newton of force to lift an apple. So if something has 10 Joules of kinetic energy it can apply a force of one Newton over a distance of 10 meters.

Here's an example: an arrow is shot from a bow and by the time it hits an apple it is traveling with 10 Joules of kinetic energy (kinetic energy is the energy of motion).

What's meant by kinetic energy is that when it hits something, it can do that much work on whatever is hit.

Soooo, back to the arrow. If the arrow hits that apple, it can exert 10 Joules of energy on that apple. It takes about 1 Newton of force to move that apple so the arrow can move the apple 10 meters. One Joule equals one Newton x one

meter so 10 Joules would equal one Newton x 10 meters.

It could also exert a force of 10 Newtons over one meter or any other mathematical calculation you'd like to play with there.

(This, by the way, is completely hypothetical. With the apple example, we are conveniently ignoring a bunch of stuff like the fact that the arrow would actually pierce the apple, and that friction, heat, sound, and a variety of other forces and energies take place here.)

The formula for kinetic energy is 1/2 mass x velocity^2 or KE = 1/2 mv^2.

We'll be doing lots of experiments to make this clearer.

Gravitational Potential Energy

There's one specific type of potential energy that's worth spending some more time on—gravitational potential energy. Gravitational potential energy is the energy something has due to gravity. This is the physics version of "what goes up, must come down".

If a ball is sitting on top of a book shelf, it has the potential to fall off. If the ball were to fall off the bookshelf it would potentially hit the floor with a certain number of Joules of energy.

The formula for this is potential energy = mass x gravity x height, or PE = mgh.

Mass is the mass of the object, gravity is the gravitational constant 10 m/s^2, and height is how high the object is above the ground.

The gravitational constant is how fast gravity accelerates things and we've generally been using 32 ft/s^2. However, since we're calculating Joules here, we need to use metric measurements. In metric measurement, the gravitational constant is 9.8 m/s^2. I tend to round that up to 10 m/s^2 to make the math a little simpler. So, let's say that a 1 kg ball is sitting on a 2 meter (about 6 feet) tall bookshelf.

That ball has potential energy, the amount of which we can calculate with PE = mgh.

PE = 1 kg x 10 m/s^2 x 2m.

Therefore, PE= 20 Joules.

It has the potential to hit the floor with 20 Joules of energy.

Transfer of Energy

Now's a good time to introduce another concept—transfer of energy. Energy changes to forms all the time. The electrical energy coming out of a wall socket transfers to light energy in the lamp. The chemical energy in a battery transfers to electrical energy which transfers to sound energy in your personal stereo. In the case of the ball falling, gravitational potential energy transfers to kinetic energy, the energy of motion.

Conservation of Energy

Energy cannot be created or destroyed in a closed system. A system is the place in which the energy is happening. In this case, the system is the ball dropping and hitting the floor. If the system is closed, that means no energy can get in or

escape from the system. Since that ball started with .7 Joules of energy, it hit the floor with .7 Joules of energy and transferred .7 Joules of energy to the floor. No energy was created or destroyed. It was just transferred within the system. As the ball dropped, it lost potential energy because it kept losing height. Also, as the ball dropped it gained kinetic energy because it kept gaining speed. So, when the potential energy was .7, the kinetic energy was 0 (not moving). When the kinetic energy was .7, the potential energy was 0 (no height). All the energy transferred during the fall.

Energy Efficiency

Now here's a question you may be asking yourself, "If energy is neither created nor destroyed in a closed system, then why doesn't a kid swinging on the playground swing go forever?

Ahhh, that's a very intelligent question. You must be very smart! Energy is neither created nor destroyed, but it can be transferred into non-useful energy. In the case of the swinging kid (picture a pendulum), every swing loses a little bit of energy, which is why each swing goes slightly less high (achieves slightly less PE) than the swing before it.

Where does that energy go? To heat. The second law of thermodynamics states basically that eventually all energy ends up as heat. If you could measure it, you'd find that the string, and the weight have a slightly higher temperature than they did when they started due to friction.

The energy of your pendulum is lost to heat! If you could prevent the loss of energy to useless energy, you could create a perpetual motion machine—a machine that works forever!

There have been a lot of folks who have spent a lot of time trying to make a perpetual motion machine, but so far, they have all failed. A perpetual motion machine is one that is said to be 100% energy efficient. In other words, all the energy that goes into it goes to useful energy. Your pendulum could be said to be about 90% efficient. Very little energy is converted into useless energy. In most systems, energy is converted to useless heat and sound energy.

Highlights for Energy

Potential energy is the amount of energy something can use to do work.

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