Name: ______________________________________ Date: ________________________

Guided Learning: Uses of Energy

Learning goals

After completing this activity, you will be able to …

- Explain how humans use various forms of energy.
- Describe the differences between different forms of energy.

Vocabulary: active noise control, diffraction, dye laser, electric motor, electromagnet, fiber optics, laser, regenerative braking

Warm-up Questions

Energy is often defined as “the ability to cause change.” Practically every process that occurs in nature involves the conversion of energy from one form to another. If energy is “the ability to cause change,” what changes do humans use energy to cause? In this guided learning, you will see some examples.

Give one example of one way humans use each of the types of energy described below:

Light energy: ____

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Electrical energy: ____

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Mechanical energy: ____

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Sound energy: ____

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Thermal energy: ____

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Light energy

The most familiar application of light energy is the light bulb. Developed in the 19th century, incandescent light bulbs produce light by using an electrical current to heat a thin wire called a filament. Other common light sources include fluorescent lamps, light emitting diodes (LEDs), and halogen lamps.

Light bulbs are most frequently used to help us see objects by sending out many streams of light, which can bounce off objects and be captured by the eye.

Light can be thought of a stream of very small electrical and magnetic forces that push each other through space. The human eye contains fluid that focuses these streams by refraction, like sunlight being bent by a prism. The lens of the eye assists in this focusing and fine tunes it so the streams converge when they hit the retina, a thin layer of cells that can react to the small electrical and magnetic forces that make up light. The retina transmits information to the brain through the optic nerve. The brain combines information from both eyes into one image.

Lasers are a more modern application of light energy. In a laser, light is reflected back and forth between two mirrors. Between the mirrors is a specially chosen material that amplifies light energy, so the light builds up inside the chamber. A small portion of this light escapes as a laser beam.

Lasers can be very powerful, and they can also be controlled very precisely. Recently, scientists have considered using lasers to push around debris in space to clear paths for space shuttles. **Dye lasers** use liquid solutions to amplify the light that passes through them. Unlike most other lasers, dye lasers allow the user to generate a wide variety of colors. A laser that can be adjusted in this way can erase scars, tattoos, and other marks on and underneath the skin.

Fiber optics is a third use of light energy. Telephone companies used to use long copper wires to send signals from one person to another. Now such information is sent through hair-thin glass cables by a series of light pulses.

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1. How do plants use light energy? ____

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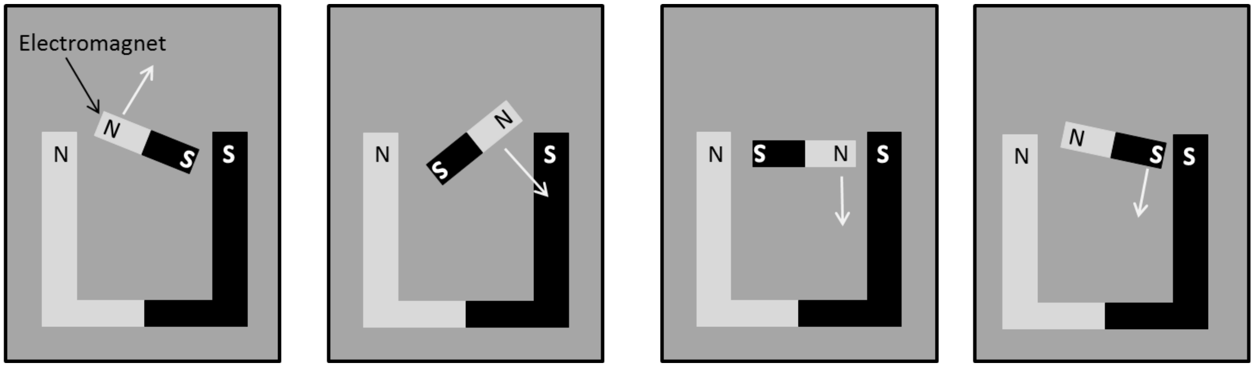
2. Candles are often used for lighting, but most of the energy they produce is not in the form of light energy. What other kind of energy do candles generate? ________________________

Electrical energy

Electric energy is used for heating and lighting. Most materials get hotter when electric current moves through them. This allows electric power to run lamps, toasters, stoves, and ovens.

When charged particles accelerate, they alter the magnetic field nearby. Certain kinds of metal can amplify this effect. This allows engineers to create **electromagnets** by wrapping wire around a piece of iron and then connecting the wire to a power source.

All magnets have two poles: one is designated as the north pole, the other as the south pole. Similar to electric charges, the north pole of one magnet will repel the north pole of another, but it will be attracted to another magnet's south pole. Changing the current's direction reverses the poles on an electromagnet. Scientists and engineers have used this idea to develop the **electric motor**, which uses electric energy to cause motion. One of the reasons electromagnets are so useful is that switching the direction of the current reverses the poles. This is the idea of an **electric motor**, which uses electric energy to cause motion.



The basic workings of an electric motor are shown above. A small electromagnet is placed between the poles of a larger magnet. The small magnet is pushed clockwise in frame 1 because the north poles repel each other, as do the south poles. This continues until the bar moves half a turn (frame 3). If nothing changed, the spinning magnet would slow down because its north pole would be pulled to the right and its south pole would be pulled to the left. However, motors are engineered so that the current in the wire around the small magnet reverses direction. This flips the north and south poles of the smaller magnet, leading to frame 4, which looks very similar to frame 1. Now the magnetic force from the larger magnet will continue to push the smaller magnet around clockwise.

The spinning magnet is connected to other parts of the motor so that when the magnet is forced to turn, it moves whatever object the motor is attached to.

Electric energy has become even more important over the last few decades because electric circuits can be used to store and process information. Most of the amazing tasks that computers do are accomplished by switching thousands or millions of tiny circuits on and off.

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Think back to the last time electric power was interrupted in your neighborhood. How did it affect how you and your family spent your time? ____

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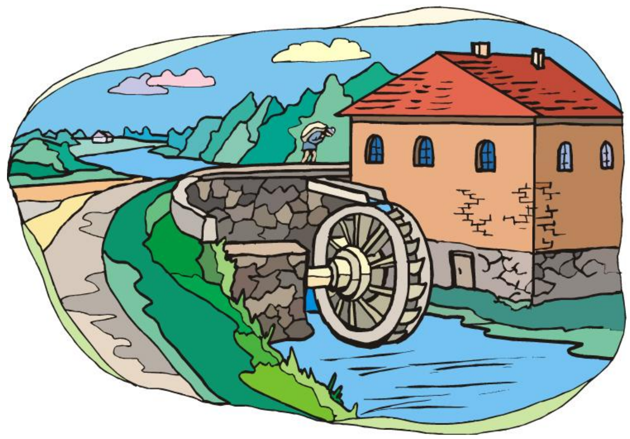
Mechanical energy

Humans have used mechanical energy for thousands of years. Cutting bread with a knife, using a pendulum to measure time, and jumping on a trampoline are all examples of mechanical energy in use. You used mechanical energy to get to school this morning, whether you walked or rode in a bus.

In previous centuries, water wheels were used to harness mechanical energy and use it to grind wheat into flour or wood into pulp. In a grist mill, a water wheel was placed near a stream or waterfall. The moving water turns the wheel, which is attached to a heavy circular grindstone. This grindstone crushes wheat to produce flour.



Scientists use mechanical energy in many interesting ways. For example, small explosions can shake the ground, causing seismic waves to pass through Earth's crust. You have probably seen light bend or reflect when it reaches glass. Seismic waves behave similarly, reflecting or changing course as they encounter different types of materials. Studying these waves allows scientists and engineers to map layers of Earth's crust and pockets of water, oil, or other valuable resources.

In the last section, you read about electric motors, which use electrical energy to produce motion. Electric motors can be used in reverse, allowing mechanical energy to generate electrical energy. This is how most power plants produce electrical power. Water is heated to produce steam. The steam rises by convection, transferring mechanical energy upward. The steam hits turbines which turn a wire coil. The coil is situated near magnets in such a way as to generate electric current when the coil rotates.

Some automobiles use the same idea to run on less gasoline. A car going 65 mph has a tremendous amount of mechanical energy. When the car slows down, it has less energy than earlier. In normal cars this means energy has been wasted. However, hybrid vehicles are designed to convert most of that energy into electrical energy, a process called **regenerative braking**. The electric energy produced in this way can later be used to run the car, meaning less energy is wasted.

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1. Consider the statement "Almost anything a human does uses mechanical energy." Do you agree or disagree? Explain your answer.

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2. Why do you think cars burn less gasoline when driving on highways than when driving through a town or city?

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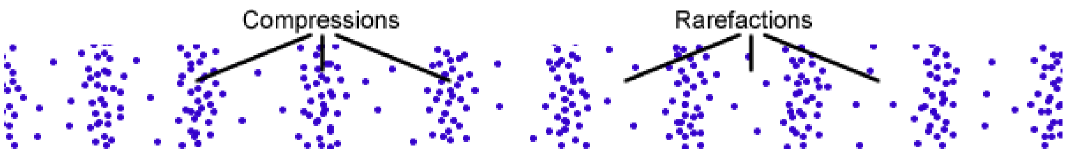
Sound Energy
The most familiar use of sound energy is the creation of music and speech. Vibrating objects cause sound by making air particles bunch up and spread out in a repeating pattern. High-pressure regions (compressions) occur where air particles bunch up. Low-pressure regions (rarefactions) occur where they are spread out more thinly than normal. A sound wave is a series of these high- and low-pressure regions that travels through space.



When a sound wave reaches our ears, the pattern of high- and low-pressure patches causes our eardrums and the nearby bones to vibrate. Our auditory nerve senses these vibrations and sends messages to the brain which interprets it as sound.

Using sound to communicate has a major advantage over the use of visual signs. Sound waves can bend around corners more easily than light can. This lets a siren or fire alarm quickly alert everyone in a location of danger. Scientists call this behavior **diffraction**.

In addition to entertainment and verbal communication, sound energy can be used in a wide variety of applications. SONAR (SOund Navigation And Ranging) uses sound waves to detect objects, much as a bat or dolphin does. It became extremely important in World War I for finding submarines and was later used to map the ocean floors.

Ultrasound is a technique used to look inside the human body by measuring sound waves that reflect from internal organs and other structures in the body. Doctors frequently use it on pregnant women to examine the fetus.

One of the most interesting uses of sound energy is to cancel unwanted sound. **Active noise control** is a technology that uses one sound wave to cancel another, generating a quiet atmosphere. For example, engine noise is a major problem for airplane pilots. A microphone can be used to measure the sound wave produced by the engine. This sound wave can be reversed using electronics and played by a small speaker in a pilot’s headset. When this reversed wave combines with the original, they cancel each other.

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1. How does sound rely on air particles? ____

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2. Do you agree or disagree with statement “Hearing an echo of your voice is similar to seeing your reflection in the mirror.”? Explain your answer.

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Thermal energy
Molecules are in constant motion. Even if a large object is at rest, the molecules that form it move in random directions that change moment to moment. The hotter an object is, the more energetically its molecules move. Thermal energy is the energy associated with these random molecular motions.

Humans often use thermal energy to maintain a comfortable temperature. If it is too cold, a fire or other source of heat can warm a building by raising the temperature of nearby air. This hotter air conveys heat to the rest of the building by conduction and convection.

Thermal energy can also be used in the treatment of sore muscles, arthritis, and similar pains. Heating a body part increases blood flow toward and away from the region. This helps the body send nutrients to the hurt area.

Thermal energy is also used in cooking. Heating food does not just change its flavor; it can also make it safer to eat. Many bacteria cannot survive high temperatures, so cooking food is a way of killing bacteria before they enter your system. Pasteurization is a similar process used to make milk and other foods safer to drink.

Many industries use a tremendous amount of thermal energy because high temperatures often allow factories to produce items quickly and efficiently. After metal is heated to the point where it melts, it can be poured into casts. This is a critical step in the manufacture of many goods. In other cases metals are melted so they can be mixed together properly, as in the production of brass and bronze. Some chemical reactions require high temperatures, and in other cases high temperatures make chemical reactions run more quickly or efficiently.

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1. If you get water from a forest stream, why is it a good idea to boil it before drinking it?

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2. How do you think the discovery of fire change the lives of primitive humans?

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3. The table below lists melting points for various metals.

Metal	Melting Point
Copper	1085°C
Tin	232°C
Iron	1538°C

Bronze is made by mixing copper and tin. Steel is made from iron. Humans used bronze materials for about two thousand years before they began making most of their tools from iron or steel. Bronze is much weaker than iron or steel. Why do you think bronze was used during that time?

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4. Why do you think it is safe to eat vegetables and fruit raw but health experts warn against eating raw meat and eggs?

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