Transforming Energy

Remember: Energy is never created or destroyed! Instead it transforms from one form to another.

We are also going to learn the magnets help generate electricity and are used in motors!

- People have been developing new ways to use energy since early humans first discovered they could burn wood to make fire for cooking and heating and also for scaring away wild animals!
- From wood to coal, and then to oil and natural gas, the ability to generate usable energy has allowed human populations to improve their quality of life and to live longer by harnessing electricity, creating new medicines and designing many other technologies that make people's lives easier.

- In recent years, as human population growth as exploded, scientists and engineers have become increasingly interested in finding the most efficient ways to transform different kinds of energy into usable energy that can do specific tasks.
- One growing area involves renewable energy sources, such as solar and wind energy.

- In this unit, you are going to use solar panels and electromagnetic motors to observe how energy is never created or destroyed but is transformed from one form to another.
- You will then take that knowledge to design vertical wind turbines and solar cars, with the goal to create the most efficient energy conversion for each!

- **Terms to know:**
- **1. Current:** a measure of the rate than an electric charge passes through a point in an electric circuit over time, and is measure in amps
- 2. **Electricity:** the flow of electrons through a conductor, a form of energy
- 3. **Electromagnet:** a tightly wound coil of insulated wire that produces a magnetic field when electricity passes through the wire
- 4. **Energy:** a force that is able to do work
- 5. **Energy Efficiency**: the amount of energy a system requires to accomplish a task compared to other systems that accomplish the same task

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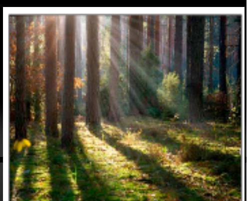
- Terms to Know:
- 6. **Energy Transformation:** The process by which energy changes from one form to another
- 7. **Force**: The energy (or effort) needed to do work
- 8. **Generator:** a machine that transfers mechanical energy into electrical energy.
- 9. **Machine:** a technology that uses mechanical energy to do work
- 10: **Magnet:** an object whose molecules are organized in such a way that their electrons spin in the same direction, creating a magnetic field.

- Terms to Know:
- 11. **Magnetic field:** an area around a charge that exerts a force on another charge
- 12. **Motor:** a machine the transfers an energy input into mechanical energy output
- 13. **Permanent magnet:** an object that stays magnetized for a long time without electricity
- 14. **Wind Turbine:** a device that concerts mechanical energy from the win into electrical power

Energy Conversions: Energy on the Move

- **Energy**—a force that is able to do work—is everywhere in the world, and it powers everything that happens in the universe.
- When the sun shines, it releases light energy.
- When that light energy hits Earth, much of it is transformed into thermal energy that warms the surface.

- Plants absorb some of the light energy and perform photosynthesis, transforming light energy into chemical energy.
- When we eat, we absorb some of that chemical energy.



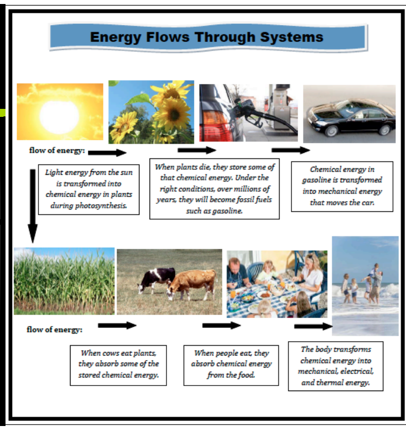
The sun releases light energy.

- When we eat, we absorb some of that chemical energy. Our cells perform cellular respiration in mitochondria to produce ATP, another form of chemical energy.
- Energy stored in ATP molecules can be converted to **mechanical energy** that powers movement, electrical energy that creates electrical nerve impulses, and thermal energy that regulates body temperature.

- When living things die, their remains keep stored energy that has not been used. That energy can be stored for millions of years as the organic remains turn into fossil fuels.
- When fossil fuels are burned, that stored chemical energy transforms into thermal energy, mechanical energy, and electric energy that we use to power our homes, cars, and other machines

Fossil fuels are valuable because they contain chemical energy.

- Energy is **always changing** from one form to another. This is called **energy transformation**, and it happens all the time.
- The total amount of energy always stays the same because energy is never created or destroyed.
- This is the **law of conservation of energy**, and it means that whenever energy is being generated, it is being transformed from one form to another.



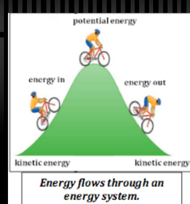
- **Changing Energy**
- All of the different forms of energy can be divided into two categories: **potential and kinetic.**

  Potential energy is energy that is being stored.
- This is energy that has the ability to do work, but is not actually doing work.
- Chemical energy, nuclear energy, and gravitational energy are all forms of potential energy.
- Energy that is released or actually doing work is **kinetic energy**.

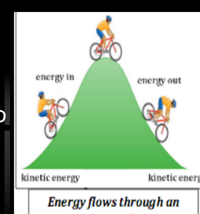
  Mechanical energy, light energy, thermal energy, sound energy, and electrical energy are all forms of kinetic energy. Each of the different forms of energy can be transformed into any of the other forms.

Anytime energy transforms from one form to another, it forms an **energy system**— a set of connected parts that transforms an input of energy into a different output of energy.

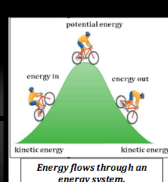
- For example, when you ride a bike, you and the bike form an energy system.



- You have **potential energy** in your body from food, which is an input of **chemical energy** because the bonds that hold food molecules together store chemical energy.
- When you move your legs, that chemical energy transforms into an output of **mechanical energy** that powers your movement.
- The mechanical energy transfers to the bike, causing the bike's wheels to turn.



- Now imagine that you want to bike up a hill. As you bike up the hill, you are converting chemical energy into mechanical energy.
- At the top of the hill, you will gain another form of **potential energy**: gravitational energy.
- The higher the rider is on the hill, the more energy is stored, and the farther the bicycle will travel once it goes down the hill.



- However, as energy transforms from one form to another, not all of the energy is transferred to a form that can do work.
- Some is usually transformed into non-usable forms of energy. The amount of energy a system requires to accomplish a task compared to other systems that accomplish the same task is called energy efficiency.
- Engineers are always looking for ways to design technologies that transform energy as efficiently as possible. They want to generate more work while using less energy.

Section 2: Part 1: Engineering Wind Turbines

- Electric Energy Engineers are particularly focused on finding renewable energy sources to generate electricity—the flow of electrons through a conductor.
- **Electricity is the most common form of energy**.
- It is found in our bodies as electrical impulses, as well as in the sky during storms as lightning.
- It also powers much of our modern world, turning on lights and powering motors.
- As human populations grow around the world, the demand for electricity is increasing

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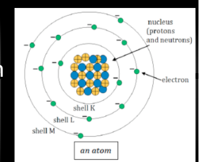
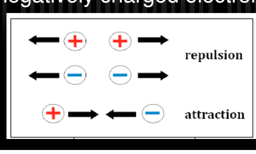
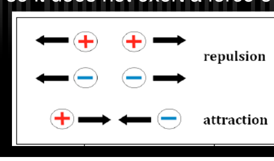
- In order to understand how electricity works, it is first important to remember that all matter is made up of atoms,
- and that atoms are made up of protons, neutrons, and electrons.
- Protons and neutrons are found in the nucleus, and electrons orbit the nucleus at different distances called shells.
- Protons have a **positive** charge (+), and electrons have a **negative** charge (-).



- The force that holds protons and electrons together in an atom is called **electromagnetic** force. It occurs whenever particles are charged, causing them to either attract or repel one another.
- Particles that have an opposite charge **attract** one another, while particles with the same charge repel each other.
- Electrons are kept in orbit in their shells because the positive charge of the protons in the nucleus attracts the negatively charged electrons.



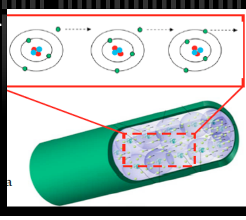
- Protons repel each other in the nucleus because they all have a **positive charge**, but they stay together because of another attractive force, called the strong force.
- The strong force counters electromagnetic force because it is the strongest attractive force, 137 times more powerful than electromagnetic force.
- However, it only exerts a force over very short distances, so it does not exert a force over electrons.



- Electrons that are in shells closest to the nucleus are tightly bound because of electromagnetic force. Just like the strong force, electromagnetic force weakens with distance, so electrons in the outermost shell are much more loosely bound.
- When a force—the energy needed to do work—is applied, electrons can be **pushed** from one atom to another. Once that first electron has been pushed away from its atom, it becomes a "free" electron and moves to another atom.
- This movement of electrons creates a chain reaction, causing electrons to all move in one direction because of electromagnetic force. It is these moving electrons that make up **electricity**.

- Electrons can move more easily through some materials than others. **Conductors** are materials that allow electricity to pass through them.
- Metals such as copper and aluminum are conductors because they have electrons that are loosely held, and therefore can easily be pushed from their shells by an outside force.
- Insulators are materials that do not allow electricity to pass through them because electrons do not easily separate from their atoms. Rubber and plastic are both good insulators. This is why electrical cords are covered in rubber or plastic.

- The electricity cannot travel through the rubber or plastic and is forced to follow the path on the aluminum or copper wires.
- Some materials are **semiconductors,** which means they can sometimes act as a conductor, depending on what other molecules are around.



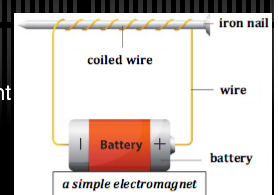
This diagram shows electricity moving through a conductor. The conductor is a wire that is made up of many atoms. Electrons move from atom to atom in a conductor.

Magnetic Fields

- Whenever an electrical charge moves, it produces a **magnetic field**—an area around a charge that exerts a force on another charge.
- When electrons spin around the nucleus, they create a tiny magnetic field.
- The positively charged protons exert a force on the negatively charged electrons, causing the electrons to orbit around the protons.

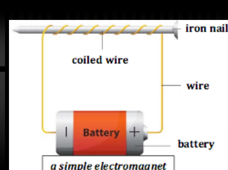
- Electric current also produces a magnetic field. Current is a measure of the rate that electric charge passes through a point on an electric circuit over time.
- A circuit is the **circular path** electrons travel in a negative to positive direction.
- All of the negatively charged electrons in a conductor are moving in one direction, and that movement produces a magnetic field around the wire conductor.

- The magnetic field around a straight wire is not very strong. However, if the wire is **wrapped in a coil**, the fields produced in each turn of the coil add up to create a stronger magnetic field.
- Because the electric current is so connected to the magnetic field, this stronger magnetic field causes the current to flow even faster.
- A faster current means that the electrons are moving faster. That faster movement stronger magnetic field, which then causes the current to move even faster.

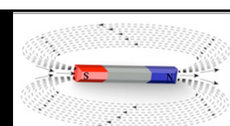


Another way to look at this is that a moving electrical current creates a magnetic field, and a moving magnetic field creates an electrical current. This tightly coiled wire that produces a magnetic field when electricity passes through the wire is called an electromagnet.

Electricity is generated from a battery that holds stored chemical energy and pushes electrons through a circuit—the circular path electrons travel in a negative to positive direction. The coiled wire is usually wrapped around a core of magnetic material, usually iron.



- Magnets



In magnets, the magnetic field flows from the north pole to the south pole.

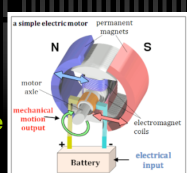
- Because electromagnets are made with **electricity**, they can be turned off if the source of electricity is stopped. Normal magnets are called permanent magnets.
- They are different from an electromagnet because once they are magnetized, they stay magnetized for a long time without an outside source of electricity. The magnets that you can put on your refrigerator are examples of permanent magnets

- Both electromagnets and permanent magnets share certain characteristics. In all magnets, the molecules are organized in such a way that their **electrons spin** in the same direction.
- A result of this organization is the creation of two poles: a north pole and a south pole.
- Magnetic force always flows from the north to the south pole, creating a magnetic field around the magnet.
- It is this magnetic field that makes magnets act the way they do.

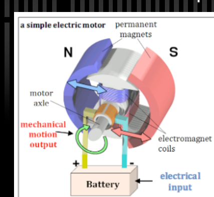
- In the same way that protons and electrons are attracted to each other in an atom, the north pole of one magnet always attracts the south pole of another.
- However, two north poles will always repel each other, as will two south poles. This is why magnets attract some magnetic objects and repel others.
- Magnets are useful because their magnetic field means they can attract or repel other magnets without coming into physical contact with the object.

Electric Motors

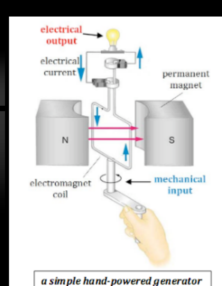
- Engineers take these concepts of electricity, magnetism, and electromagnetic force to design **machines**— technologies that use mechanical energy to do work.
- Many machines use motors, which transfer an energy input into mechanical energy output.
- Electric motors use both electricity and magnets to create motion.
- **They have two parts: an outside permanent magnet and an inside electromagnet.**



- The permanent magnet and electromagnet both have a magnetic field with a north and south pole.
- The two north poles will always **repel** each other, as will the two south poles, while the north pole will attract the south pole of the other magnet.
- If the electromagnet is positioned so that its north pole is near the north pole of the permanent magnet, the two magnets will repel each other, and be attracted to each other's south pole.



- These attracting and repelling forces cause the electromagnet to rotate, generating mechanical energy.
- This mechanical energy can be used for many different kinds of work.
- Small electric motors are found in almost all objects that move including electric toothbrushes, power windows in cars, electric clocks, and many children's toys.



a simple hand-powered generator

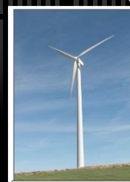
TOMORROW: BLOCK DAY1

- Tomorrow we will be "dissecting" a motor so you can see what is inside, and how the magnet works!
- PLEASE be sure to bring this packet tomorrow to class!

Capturing the Wind

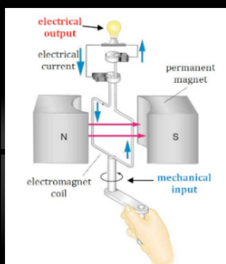
- People have known for centuries that the wind has **mechanical energy** that can be used to do work. Ancient sailors used the wind to power their movement on the oceans, and generations of farmers used the wind's energy to pump water and grind grain.
- Today, wind is used primarily to generate electricity.
- One of the most common ways to harness the wind's energy is with a wind turbine—a device that converts the wind's mechanical energy into electricity.

- Turbines can be as tall as a 20-story building and have blades that are 60 meters (200 feet) long. Basic wind turbines have three parts: **blades, a drive shaft, and a generator**—a machine that transfers mechanical energy into electrical energy.


horizontal-axis wind turbines


vertical-axis wind turbine

- The generator uses the same principles of electromagnetic force as an electric motor, but it works in reverse.
- A generator uses mechanical energy to move a magnet near a wire conductor, which creates a flow of electrons, generating electricity.

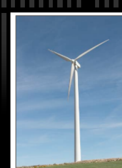


a simple hand-powered generator

The blades of a wind turbine capture the wind's **kinetic energy.** The wind pushes on the blades, transferring some of its own mechanical energy of motion to the blades.

The blades are connected to a drive shaft, which is a long bar of steel that can rotate. As the wind moves the blades, the blades rotate the drive shaft.

That rotating motion moves the magnet in the generator, which produces electricity.


horizontal-axis wind turbines


vertical-axis wind turbine

Turbine Design Challenges

- Engineers experiment with different blade shape and size depending on the specific environmental conditions.
- There are two basic designs: **vertical-**axis wind turbines and **horizontal**-axis wind turbines.
- Horizontal-axis turbines are much more common because they are generally more efficient at converting the wind's mechanical energy into electricity.
- They look like massive airplane propellers on a pole. However, horizontal-axis wind turbines work most efficiently when the wind flows at a **right angle** to the blades.

Turbine Design Challenges

- This means that the main rotating shaft and electrical generator must be pointed into the wind.
- They are also very tall, with long blades. This makes them best suited for open spaces, such as fields, that have a lot of wind. The more mass the blades have, the more force is needed to turn them.
- The other kind of turbine is called a **vertical-axis** wind turbine, and it often looks like a massive egg beater. In this kind of wind turbine, the main drive shaft is **perpendicular** to the ground. The main components are located at the base, making any service and repair much easier.

Turbine Design Challenges

- One advantage of the vertical-axis wind turbine is that it does not need to be pointed into the wind. **It will function similarly regardless of wind direction**.
- This makes it a better option for many urban areas where tall buildings make wind flow more unpredictable.
- However, this design is less efficient than horizontal-axis wind turbines because the blades rotate more slowly.