I'm Surecuit Works?

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Field(s) of Interest: Engineering (Electrical & Mechanical)

Brief Overview:
Mentees will learn all about circuits and be given the opportunity to design their own light-up LED name tag. They will also learn how to power a simple motor using batteries and pager motors!

Agenda:

- Introduction (5 min)
- Module 1: Light it Up (5-10 min)
- Module 2: What's your name again? (15-25 min)
- Module 3: Bristle Bot Battle (20-25 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:

- ➔ Electrons
- ➔ Electrical Energy
- ➔ Open/Closed Circuit
- ➔ LED
- ➔ Conductor
- ➔ Insulator
- ➔ Battery
- ➔ Anode
- ➔ Cathode
- ➔ Ohm's Law
- ➔ Mechanical Energy
- ➔ Motor
- ➔ Magnetic Field
- ➔ Commutator

Background for Mentors

Module 1

- Electrons
- Electrical Energy
- Open/Closed Circuit
- LED

Electricity is the movement of tiny charged particles called **electrons**. Electrons are found inside atoms and can move through certain materials, especially metals such as copper. When electrons move together through a material, they create an electric current. This current is what powers many of the devices we use every day, including phones, lights, and computers.

Electrical energy is the energy carried by moving electrons. Just like other forms of energy, electrical energy can be converted into different types of energy. For example, a light bulb converts electrical energy into light and heat. A motor converts electrical energy into motion.

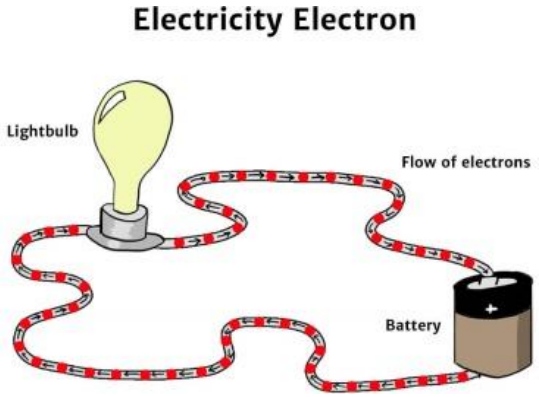

Figure 1: Flow of electrons moving from battery to power lightbulb

A **circuit** is a complete path that allows electrons to flow from a power source, through components, and back to the source again. If the path is incomplete, the electrons cannot move and the device will fail.

The circuit must be complete for electrons to keep flowing. A **closed circuit** occurs when the path from the battery, to the conductive materials, through the device, and back to the battery is fully connected. When a circuit is closed, electrons can flow through the wires or copper tape and deliver electrical energy to the device.

If there is a break anywhere in the path, it becomes an **open circuit**. In an open circuit, electrons cannot travel through the entire pathway, so electrical energy cannot reach the device. This event can happen if a wire becomes disconnected, if copper tape pieces are not touching, or if a switch is turned off.

An **LED**, or **light-emitting diode,** is a small electronic component that produces light when electricity flows through it. LEDs are commonly used in

	electronics because they require very little electrical energy and are very efficient. When electrons flow through the LED, electrical energy is converted into light energy. LEDs are slightly different from many other electronic components because they only allow electricity to flow in one direction. This means the LED must be placed correctly in the circuit in order for it to light up.

Module 2

- Conductors
- Insulators
- Battery
- Ohm's Law
- Anode
- Cathode

For electricity to move through a circuit, the materials in it must allow electrons to flow. Materials that allow electrons to move easily are called **conductors**. Metals such as copper are effective conductors because electrons can travel through them with little resistance.

Materials that do not allow electrons to move easily are called **insulators**. Insulators prevent electricity from flowing freely. Common examples include plastic, rubber, wood, and paper. Insulators are important because they help control where electricity travels and keep users safe.

Ohm's Law (V = IR) describes the relationship between voltage, current, and resistance in a circuit. In this equation, **V** represents voltage, which is the electrical push provided by the battery. **I** represents current, which is the flow of electrons through the circuit. **R** represents resistance, which describes how much a material opposes the flow of electricity. Conductive materials like copper have low resistance, allowing current to flow easily through the circuit.

A **battery** is a device that stores chemical energy and converts it into electrical energy. When connected to a circuit, the battery provides the energy that pushes electrons through the conductive pathway.

Batteries have two terminals called the **anode** and **cathode**. The anode is the negative side where electrons leave the battery, and the cathode is the positive side where electrons return after traveling through the circuit. LEDs also have an anode and cathode, which means electricity can only flow through them in one direction. If the LED is placed in the circuit backwards, it will not light up.

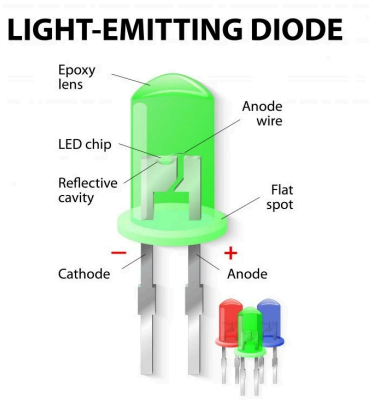

Figure 2: LED and all of its different components to light up

Module 3

- The scientific method
  - Observe
  - Question
  - Research
  - Hypothesize
  - Experiment
  - Analyze results

Mechanical energy is the energy associated with motion or the position of an object. When something moves, spins, or pushes another object, it is using mechanical energy. Many machines convert other forms of energy into mechanical energy to perform useful work. For example, fans, drills, and electric cars all use electricity to produce motion.

A **motor** is one type of machine that changes electrical energy into mechanical energy. A motor is a machine that uses electricity to create motion, usually in the form of rotation. When electricity flows through the wires inside a motor, it interacts with magnetic forces that cause parts of the motor to spin. This spinning motion is the mechanical energy that powers many everyday devices such as fans, toys, and appliances.

Motors work because electricity and magnetism are closely connected. When electric current flows through a wire, it creates a **magnetic field** around it. A magnetic field is the region around a magnet or electric current where magnetic forces can be detected. Inside a motor, these magnetic fields interact with magnets or other magnetic fields, producing forces that cause the motor's coil or shaft to rotate.

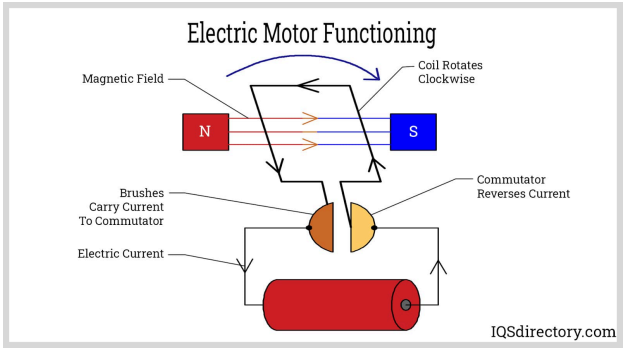

Figure 3: Full picture of how an electric motor functions with magnetism

But the electrical current's direction must change at the right time in each rotation to keep the motor spinning. This is accomplished by a component called a **commutator**. A commutator is a rotating electrical switch that periodically reverses the direction of current in the motor's coil. By reversing the current at the right time, the magnetic forces continue to push the motor in the same rotational direction, allowing it to spin continuously.

Introduction

Concepts to Introduce ● Electricity is the movement of tiny particles called electrons through materials like wires. For electricity to work, it needs a complete path called a circuit. ● Electrical energy can be converted into other forms of energy, such as light in LEDs or motion in motors ● Have mentees points at the things in the room that require electricity ● Electricity can be explained as water flowing through a pipe.	**Questions to Pique Interest** ● How does flipping a light switch make a light turn on instantly? ● Why do some devices use batteries while others plug into the wall? ● How can electricity make something move, like a fan, toothbrush, or toy car?
Scientists, Current and Past Events ● **Benjamin Franklin** helped study electricity and showed that lightning is a form of electricity. ● **Thomas Edison** helped develop practical electric lighting and early power distribution systems.	**Careers and Applications** ● Electrical engineers design circuits and electronics used in devices like phones, computers, and robots. ● Engineers work on technologies such as electric vehicles, renewable energy systems, and power grids that deliver electricity to homes. ● Technicians and engineers also build and maintain electronic devices, appliances, and motors used in everyday life.

Module 1: Light It Up

Mentees will do a fun cooperative activity by imitating how a circuit works. Mentees will pass ping pong balls, which are electrons, to each other by rolling up paper. Once they reach a mentor, the LED will “light up”.

Teaching Goals	**Materials for demo**
1. **Electrons:** Negatively charged particles that move through conductive materials to create electric current. 2. **Electrical energy:** Energy carried by moving electrons in a circuit. 3. **Open circuit:** A circuit with a break in the path that prevents electrons from flowing. 4. **Closed circuit:** A complete circuit path that allows electrons to flow. 5. **LED (Light Emitting Diode):** An electronic component that produces light when electric current flows through it.	● Ping Pong Balls ● Laminated Paper

Different Methods for Teaching

1. **Electrons:** Electrons are like tiny balls moving through wires. In the activity, the ping pong balls represent electrons. Just like the balls roll down the paper cylinders, electrons move through wires to carry electricity through a circuit.
2. **Electrical energy:** Electrical energy is the energy carried by moving electrons. A simple way to explain this is to compare it to water flowing through pipes. When water moves through pipes, it can turn a water wheel. In the same way, when electrons move through a circuit, they carry energy that can power things like LEDs.
3. **Open versus closed circuit:** A closed circuit is like a set of tracks that allow a train to move in a circle without stopping. An open circuit is if one of the tracks was removed and the train could not move.
    a. You could also compare this to a drawbridge connecting roads so cars can go over water.

Procedure for the demo

1. Have mentees arrange them into a straight line and give each of them a laminated sheet of paper.
2. Roll up the laminated paper so it is in the shape of a half cylinder.
3. Place the rolled-up sheet of paper between other mentees' papers to act as wires.
4. Start placing ping pong balls at the start where the battery is and have mentees try to roll the ping pong balls down their paper cylinder to the end.
5. If a mentee drops their paper, this is called an open circuit, but when there is a continuous flow, this is a closed circuit.
6. After the mentor receives the first ping pong ball, start jumping up and down until all ping pong balls are at the LED.

Figure 3: The setup for passing the ping pong balls.

Classroom Notes: If it's hard to set all your mentees up in a line due to limited space, you can also have them in a circle around the room and just pass each other the ping pong balls rather than using the laminated paper.

Module 2: What's Your Name Again?

Mentees will create their own light up LED name tag using simple circuits, a 3V coin cell battery, and conductive copper tape.

Teaching Goals	**Materials (Per mentee)**
1. **Conductor:** A material that allows electrons to move easily through it. 2. **Insulator:** A material that resists the flow of electrons and prevents electricity from passing through easily. 3. **Battery:** A device that converts stored chemical energy into electrical energy to power a circuit. 4. **Ohm's Law:** The relationship between voltage, current, and resistance in a circuit, expressed as V = IR 5. **Anode:** The terminal where electrons leave a component or device. 6. **Cathode:** The terminal where electrons enter or return to a component or device.	• One (1) cut out name tag instruction sheet • One (1) 3V cell battery • One (1) Copper tape strip • One (1) Sticky Name Tag • One (1) LED

Different Methods for Teaching

1. **Conductor versus insulator:** Explain that a conductor is like a smooth road that lets electrons travel easily. Copper tape in the activity acts like this road, allowing electricity to move through the circuit. An insulator is like a wall that blocks the road. Materials like paper or plastic stop electricity from moving through them, which helps keep the circuit controlled and safe.
    a. Call back to Jared's lesson where we introduced conductors and insulators in the spoon activity and saw how they affect the flow of heat!
2. **Battery:** The battery is what pushes electrons through the circuit. A good comparison is water in a hose. The battery is like the water pump that pushes the water through the hose so it can reach the end. In the name tag circuit, the 3-volt coin battery pushes electrons through the copper tape and into the LED so it can light up.
    a. Could also ask mentees what items have batteries
3. **Anode versus cathode:** Explain that electricity needs a place to start and a place to finish. The anode is like the exit door where electrons leave, and the cathode is like the entrance door where electrons come back in.

Procedure

1. Place the name tag sticker onto the LED name tag instruction sheet. Make sure it is centered.

2. Puncture the LED through the paper and spread the legs out to follow the written setup.
    a. The short leg of the LED should be pointed to the right, and the long leg should be pointed down.
3. Place one strip of copper tape on the **A** outline. Make sure that it covers only the short LED leg.

4. Place the battery onto its respective place so that it sits on top of the copper tape

5. Place another piece of copper tape that goes from the top of the cell battery to the designated location on the paper **strip E.** Make sure the copper tape keeps the battery cell in place.

6. Place another piece of copper tape on **Strip D**.

7. Finally, place your last piece of copper tape on **Strip C** and verify that it lies **only** on top of the long LED leg. If the copper tape on C touches the short leg or **Strip A,** it will not work.

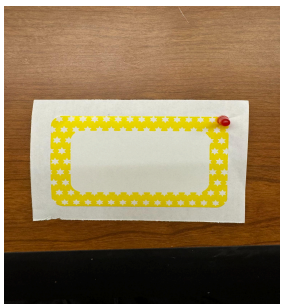

Figure 4: Punctured LED through the paper and name tag

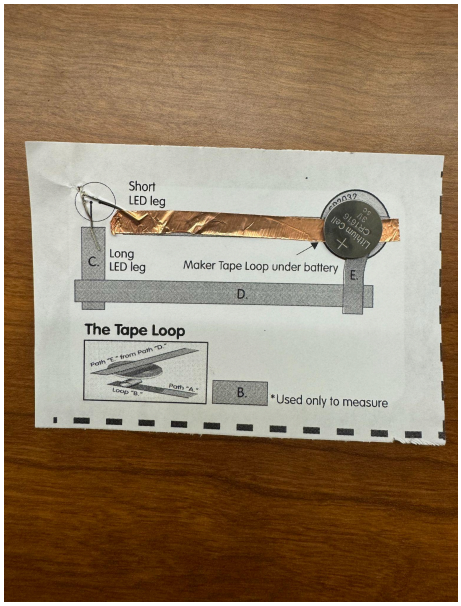

Figure 5: Copper tape placed on short LED leg and the 3V battery on top

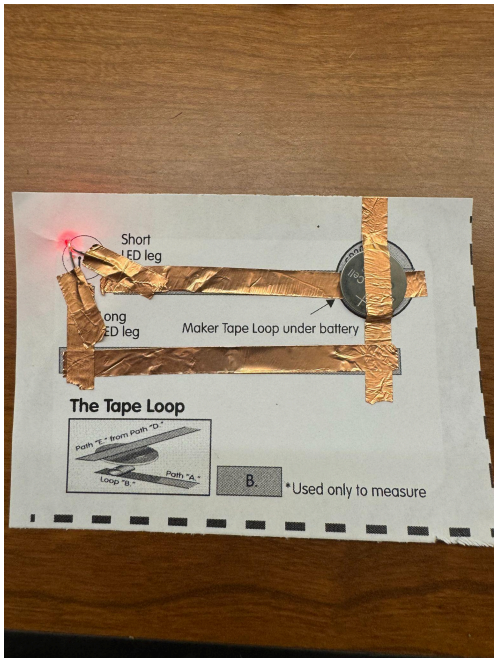

Figure 6: Finished LED circuit with copper tape attached to the Long LED leg

Classroom Notes: Confirm that the mentees have arranged the LED legs correctly before taping.

Module 3: Bristle Bot Battle

Mentees will make vibrating toothbrush bots that are capable of moving on their own with the help of a 3V cell battery and a pager motor. They will get to take it home as well!

Teaching Goals	**Materials (Per Mentee)**
1. **Mechanical energy:** The energy associated with motion or the position of an object. 2. **Motor:** A device that converts electrical energy into mechanical energy, usually by producing rotation. 3. **Magnetic field:** The region around a magnet or electric current where magnetic forces can act. 4. **Commutator:** A rotating electrical switch in a motor that reverses the direction of current in the coil to keep the motor spinning.	• One (1) Toothbrush head • One (1) Pager motor • One (1) 3V cell battery (Reuse the one from name tag) • Two (2) Pipe cleaners • Two (2) double-sided tapes • Two (2) Glue dots

Different Methods for Teaching

1. **Mechanical energy:** Mechanical energy is the energy of movement. A good example is riding a bike or kicking a soccer ball. When something moves, spins, or rolls, it is using mechanical energy. In the activity, when the toothbrush starts shaking and moving across the table, that movement is mechanical energy.
2. **Motor:** A motor is a device that turns electricity into motion. You can explain this by pointing to everyday objects like electric fans, toy cars, or electric toothbrushes. When you turn on a fan, electricity goes into the motor and the blades start spinning. In the activity, the small pager motor makes the toothbrush vibrate and move.
3. **Magnetic field:** A magnetic field is an invisible force around a magnet or electric current. A simple example is putting a magnet on a refrigerator. The magnet sticks even though we cannot see the force holding it there. Inside the motor, magnetic forces push parts of the motor to spin.
4. **Commutator:** The commutator helps the motor keep spinning instead of stopping. A simple way to explain this is with a playground swing. If you push someone on a swing at the right time every time it comes back, the swing keeps moving. The commutator does something similar inside the motor by switching the direction of electricity at the right moment so the motor keeps spinning.

Procedure

1. Take one side of the double-sided tape and place the blue wire from the pager motor onto it
2. Place the 3V cell battery on top of the blue wire and tape.
3. Remove the covering on the double-sided tape, and place it onto the top of the toothbrush head. Make sure that it is centered on the toothbrush.
4. Take the tape off the pager motor and place it toward the stem of the toothbrush.
5. Bend pipe cleaners into 90 degrees and place glue dots on the middle of each one. Place these pipe cleaners onto the front and back of the toothbrush. (This is optional if the toothbrush is not standing upright.)
    a. Make sure to angle the legs of the pipe cleaners so that they touch the ground and help it stand.
6. Take the second piece of double-sided tape and put it on the red wire.
7. Finally, place the taped red wire onto the top of the 3V cell battery and watch it move!

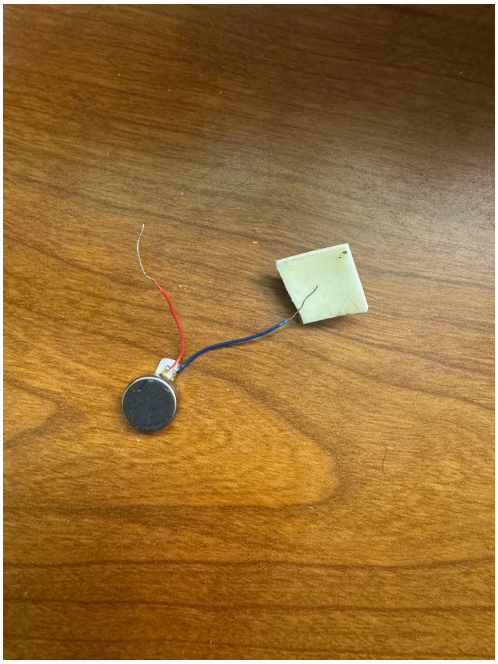

Figure 7: Blue wire attached to one side of the double-sided tape

Figure 8: 3V cell battery is placed on top of the blue wire. The back side of the double sided tape is removed and placed on the toothbrush

Figure 9: Optional but green pipe cleaners placed on tooth brush ends.

Classroom Notes

Make sure that the blue wire is touching the bottom of the 3V cell battery and the red wire is touching the top wire. If it is not standing upright, add the pipe cleaners onto the ends.