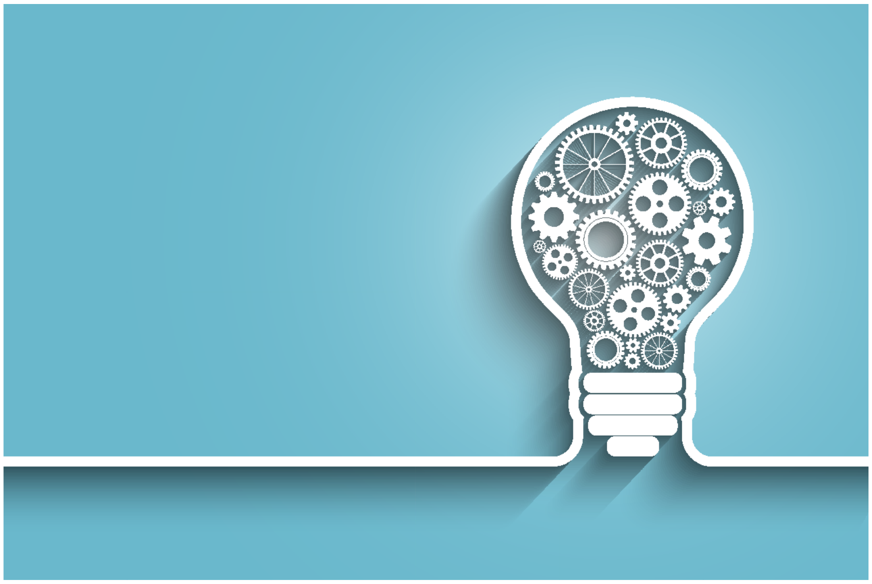
Junior Lab: Leader's Meeting Preview and
"How Things Work" Meeting Plan



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HOW THINGS WORK

The adult leaders should read through all the meeting activities ahead of time. If this is your first time managing a Lab, please review the Lab Leaders Operations Guide, which contains general instructions, lab setup information, the Scout Oath and Scout Law, and more.

Print DOUBLE-sided

Pledge of Allegiance, Scout Oath, and Scout Law

Prior to every meeting, have a Scout volunteer to lead the group in the Pledge of Allegiance, the Scout Oath, and the Scout Law.

Pledge of Allegiance (hand over heart)

I pledge allegiance to the Flag of the United States of America, and to the Republic for which it stands, one Nation under God, indivisible, with liberty and justice for all.

Scout Oath (Scout sign)

On my honor I will do my best to do my duty to God and my country and to obey the Scout Law; to help other people at all times; to keep myself physically strong, mentally awake, and morally straight.

Scout Law (Scout sign)

A Scout is—
Trustworthy
Loyal
Helpful
Friendly
Courteous
Kind
Obedient
Cheerful
Thrifty
Brave
Clean
Reverent

MODULE OVERVIEW

Force, acceleration, and energy—oh my! From the small thoughts of "I wonder…?" to BIG discoveries, Galileo and Isaac Newton set the foundation of physics as we know it today. From understanding gravity, acceleration, and the transfer of energy, we can look at movement in a whole new light.

In this module, Scouts will gain a basic knowledge of Newton's three laws of motion through hands-on application and discovery as they build inclined planes, roller coasters, a balloon-powered plane, and circuit boards. Through challenge-based learning, Scouts will begin to understand how the world around them moves. Let's spark some curiosity!

Grades 3–5
Next Generation Science Standards:
3-PS2-1, 3-PS2-2, 4-PS3-1, 4-PS3-2, 3-5-ETS1-3

MODULE COAUTHORS

Some lessons in this module were developed for STEM Scouts by Eduporium. Eduporium (www.eduporium.com) is an all-encompassing partner of schools, districts, and educational organizations, specializing in creating innovative educational and computer technology solutions to enhance the meaningful use of STEM technology in education and to help students develop crucial 21st-century skills. Their experts creatively combine technology tools into custom solutions for use in classrooms, makerspaces, libraries, and after-school programs. Eduporium encourages early exposure to invention, problem-solving, coding, and collaboration in an effort to inspire lifelong STEM learning for our educators and future generations in the classroom!

Meeting 1: Motion Madness—Part 1 (75–90 minutes)
Through hands-on exploration, Scouts will experience Newton's three laws of motion to gain the foundational knowledge of gravity and motion. Then, through creative collaboration, Scouts will engineer an inclined plane.

Meeting 2: Motion Madness—Part 2 (75–90 minutes)
Scouts will explore the properties of energy and discover more about potential and kinetic energy. They will test the inclined plane they built in Meeting 1, conduct trials to analyze speed, and calculate averages.

Meeting 3: Speed Machine (75–90 minutes)
Scouts will explore Newton's second law of motion to discover more about force and acceleration. Then, through creative collaboration, Scouts will design and engineer their own roller coaster out of various materials, relying on gravity as their source of power and speed.

Meeting 4: Follow the Flow (75–90 minutes)
Scouts will explore Newton's third law of motion and understand the particles that make up an atom as they explore the flow of electric currents. They will also discover the difference between conductors and insulators as they design their own circuit out of various materials to light up Christmas lights using a 9-volt battery as their power source.

Meeting 5: Fly, Saucer, Fly! (75–90 minutes)
Scouts will learn what a simple circuit is and how switches control the flow of the electric current. They will also explore how loads function in a circuit by building various circuits to fly the saucer, sound the horn, and light the lamp.

Meeting 6: Working Together in Series (75–90 minutes)
Scouts will learn what parallel, series, and combination circuits are and how they differ from one another. They will build each type of circuit using switches and various loads. *Leaders, please complete the survey at end of module; pg. 101.*

Weekly Meeting Prep at a Glance

The following are lists of kit materials as well as council- and unit-supplied materials for this module. Unit-supplied materials can often be supplied by parents if requested well in advance.

PLEASE USE PACKING SLIP to check kit contents **one week prior** to first meeting. Slip can be found in the Kit Shipment email and/or the STEM Scouts Portal (where this guide was downloaded). Please **DO NOT** skip this part!

Scouts will be divided into teams of **THREE** for this module. Material quantities are defined below for **EACH TEAM**.

Meeting 1

Materials From Kit

- 1 Engino® Newton's Laws Kit—Inertia, Momentum, Kinetic & Potential Energy
- 1 stopwatch
- 1 golf ball
- 1 plastic cup
- 1 sheet of paper

Printed Materials

- Meeting 1 handout sheets from *Scout Notebook*

Materials Needed But Not Provided in Kit

- N/A

Meeting 2

Materials From Kit

- 1 Engino® Newton's Laws Kit—Inertia, Momentum, Kinetic & Potential Energy
- 1 inclined plane model from Meeting 1
- 1 stopwatch
- 1 calculator
- 1 marble
- 1 golf ball
- 1 ping-pong ball
- 1 measuring tape
- Masking tape

Printed Materials

- Meeting 2 handout sheet from Scout Notebook

Materials Needed But Not Provided in Kit

- N/A

Meeting 3

Materials From Kit

- 2 manila folders
- 4–5 feet of masking tape
- 1 pair of scissors
- 1 marble
- 1 golf ball
- 1 ping-pong ball
- 1 measuring tape
- 1 stopwatch
- 1 calculator
- 1 clear plastic cup
- 1-foot string
- 3 balloons

Printed Materials

- Meeting 3 handout sheet from Scout Notebook

Materials Needed But Not Provided in Kit

- N/A

Meeting 4

Materials From Kit

- 5 sheets of foil
- 1 pair of scissors
- 5 Christmas lights
- Clear tape
- 5 paper clips
- 2 9-volt batteries
- 10 chenille stems
- 2 feet of string
- 3 manila folders
- 5–6 craft sticks
- 3 balloons

Printed Materials

- Meeting 4 handout sheets from Scout Notebook

Materials Needed But Not Provided in Kit

- N/A

Meeting 5

Materials From Kit
- Snap Circuits® Flying Saucer Plus Kit
- 3 AA batteries
- Markers
- 1 pair of scissors
- Tape

Printed Materials
- Meeting 5 handout sheet from Scout Notebook

Materials Needed But Not Provided in Kit
- N/A

Meeting 6

Materials From Kit
- Snap Circuits® Flying Saucer Plus Kit
- 3 AA batteries

Printed Materials
- Meeting 6 handout sheets from Scout Notebook

Materials Needed But Not Provided in Kit
- N/A

Service Project Idea: Giving Back!

After Scouts complete this six-week module, Scouts can work with their school on spreading awareness about energy conservation!

Check the STEM Scout Portal download files for more service project ideas!

Meeting Facilitation Tips

- Choose an **attention getter** with your Scouts. This is a “call and response” technique used to capture the Scouts’ attention for a focused moment.

  Step 1: Have Scouts *vote* on an attention getter. For example, you could use

Making the Scout salute, you say:	Making the Scout salute, they respond:
One, two, three!	All eyes on me!
Scout’s honor!	Scout’s duty!
Potential energy!	Everybody freeze!
Holy moly!	Guacamole!

  Step 2: Have Scouts decide *with you* what is expected when this attention getter is used.

  For example, the expectations may be to have mouths closed, hands still, ears open, and eyes on you. (Post the expectations, if possible.)

  Step 3: Practice!

- For a **calming moment** at any point during the activity, get the Scouts’ attention by using the attention getter, then have them take two or three deep breaths together to reset or refocus.

- **“Guide by the side.”** Walk around the space to guide Scouts through the activity. Instead of giving the answers, ask open-ended, leading questions to help them think through the challenges.

  Note: This is a *safe* time for Scouts to discover, experiment, and even possibly fail. This helps build a growth mindset and resilience. What matters is how much *effort* we put into our work, not our ability to get it right the first time. That’s what STEM is all about—failure is a part of the process!

- To help the various types of learners, use the **Key Terms** page in each meeting plan for Scouts to pass around, hold, and read. Note: If possible, post these terms in the room.

- **Meet the Scouts where they are.** Use the Activity Adaptations section in the meeting plan to adjust activities based on each Scout’s behavior and/or ability. If you notice a Scout struggling with an activity or a Scout who has finished early, use these adaptations to continue to keep the Scout engaged and excited about learning.

- **Team dynamics.** If teams are too rowdy or you notice some unhealthy team behavior, feel free to move members to different teams at any time. This will help to establish a better learning environment, and it will support you in facilitating and “guiding by the side.”

- **Remember,** it’s OK if you don’t know the answer to something. Discover *with* the Scouts and learn together!

MEETING PREVIEW AND SETUP

Meeting 1: Motion Madness—Part 1	**STEM Focus:** Physics

After this meeting, Scouts will be able to

- Describe potential and kinetic energy
- Build an inclined plane
- Understand gravity and Newton's first law of motion

Scout Law Character Focus

Helpful

Total Meeting Time

75–90 minutes

Opening (Pledge, Oath, Law):

10 minutes

Activity Introduction:

5–10 minutes

Safety Moment:

1–2 minutes

Activity:

45 minutes

Reflection:

5–10 minutes

STEM Innovator Moment:

2 minutes

Announcements/Cleanup:

5–10 minutes

Meeting Prep Time: 30 minutes

Activity Prep

- **Collect** supplies needed for meeting
- **Scout Notebook:** Meeting 1 (one per team). NOTE: Scout teams will turn this in after each meeting to use for the entire module.

Space Needed

Tables or a space for Scouts to design and build models

Teams of Three

OPTIONAL: In each team, there will be three roles. Have Scouts get into teams and decide who will take each role **before the lesson begins**:

Project Manager (PM)—Gathers and manages all materials for the team. Oversees overall success of the project.

Principal Investigator (PI)—Leads observation and documents findings in the Scout Notebook.

Co-Principal Investigator (Co-PI)—Assists the PI and makes sure that everyone has a chance to participate.

Materials From Kit <u>Per Team</u>	**Materials Needed But NOT Included in Kit**
• 1 Engino® Newton's Laws Kit—Inertia, Momentum, Kinetic & Potential Energy • 1 stopwatch • 1 golf ball • 1 plastic cup • 1 sheet of paper • Masking tape (to tag each team's plane after assembly)	• N/A **Lab Leaders Optional Notes Section** *(This section is for YOU! List notes, reminders, and/or responsibilities and roles of the Scouts. You may also create a list of successes and challenges you experience during this activity and send it our way!)*

MEETING PLAN	
Meeting 1: Motion Madness—Part 1	**STEM Focus:** Physics

Activity Overview

Through hands-on exploration, Scouts will experience Newton's three laws of motion to gain the foundational knowledge of gravity and motion. Then, through creative collaboration, Scouts will engineer an inclined plane.

PART 1

Introduction/Background Information

Use the questions and background information below to engage Scouts. *(Typical answers are in italics.)*

Break Scouts up into teams of three before beginning the introduction.

- In this module, we are going to be discussing how things work—things like an inclined plane, roller coasters, and even electric currents!
- To explore these things, we need to learn more about gravity, motion, and a man named Isaac Newton.
- First, let's talk gravity. What is gravity? *(Refer to the key term on page 25. Gravity is the force that pulls other objects toward the center of the earth.)*
- Gravity is a force that attracts any objects that have mass—for example, you and me, buildings, and even the moon. We attract each other and we attract the earth. On our planet, the force of gravity is mostly from the earth, but ocean tides happen because of the gravitational pull of the moon.
- *(Grab a piece of paper.)* What will happen if I let go of this sheet of paper? *(It's going to fall because gravity is pulling it down to the center of the earth.)*
- *(Drop the paper.)* The paper fell to the ground—it received motion from the Earth's gravitational pull!
- Does anyone know the two terms that describe an object in motion and an object at rest? *(Use the key terms on pages 25-27 to review the points below.)*
- **Potential energy** means that the object has energy, but it doesn't move. Think of a battery. When a battery is connected, the energy is released but the battery itself doesn't move. It had potential energy.
  - Some objects can be at rest and have potential energy simply because of gravity. For example, a cup sitting on a desk: It has potential energy because gravity is acting on it and it has the potential to fall, spill, and continue to fall however far gravity will take it!
- **Kinetic energy** is the energy associated with any moving object. Kinetic energy means that the object IS moving. *(Have Scouts repeat this sentence out loud)*.

- The paper that was dropped had **potential energy** when I was holding it in the air. When I dropped it and gravity pulled it to the ground, it had **kinetic energy** that was moving it to the floor.

- Gravity, motion, and energy often are linked to each other, and Isaac Newton understood that.

- Does anyone know who Isaac Newton was? Isaac Newton was a scientist born in 1643. He formed the basic principles of physics in what we call the three laws of motion.

- Newton's three laws of motion are (*use the key terms on page 27*):

  1. An object that is at rest or moving at a constant speed in a straight line will stay like that until it is acted upon by another force. We call this **inertia**. *(Have Scouts repeat the word out loud.)* Inertia means that things in motion tend to stay in motion, and things at rest tend to stay at rest.

  2. **Acceleration—**or, changing the movement of an object—depends on the mass of the object and the amount of force being applied.

  3. For every action, there is an equal and opposite reaction.

- Over the next three meetings, we are going to explore Newton's three laws of motion. Today, we are going to do a short experiment with the first law, and then your team will build an inclined plane!

- Follow the steps in your Scout Notebook to do the experiment for Newton's first law. *(This should take only five to seven minutes. The steps are listed below for Lab Leader reference.)*

  - **Materials for each team:** 1 plastic cup, 1 golf ball, and 1 sheet of paper
    1. Fold the paper three times lengthwise to make a trifold, rectangular shape.
    2. Place one end of the folded paper over the cup of water to cover the top.
    3. Balance the golf ball on the end of the paper that sits over the cup.
    4. The Co-PI should hold the cup still and steady.
    5. The PI will quickly and carefully pull the paper out from under the golf ball.

- Now, let's talk about an **inclined plane**. What is an inclined plan? *(A flat, supported surface tilted at an angle, also known as a ramp.)*

- Who can think of an inclined plane that we see in real life? *(A slide, a wheelchair ramp, a skateboard ramp, a truck-loading ramp, etc.)*

- Finally, let's build our inclined plane. You will follow the steps in your Scout Notebook to get started.

PART 2

Discuss the Scout Law Character Focus

Today we are focusing on the character point **Helpful**.
What does it mean to be helpful? *(To give service or assistance to others.)*
How can we practice being helpful today during our activities?

PART 3

Safety Moment

- Small pieces are included. Do not put any of them in your mouth!
- When snapping the pieces together, be careful to not hurt your fingers.
- When pulling the pieces apart, be gentle to avoid breaking them.

PART 4

Leader Note

When the meeting is over, *use the masking tape to make a small tag with each team’s name on it so that they can identify their inclined plane at the next meeting.*

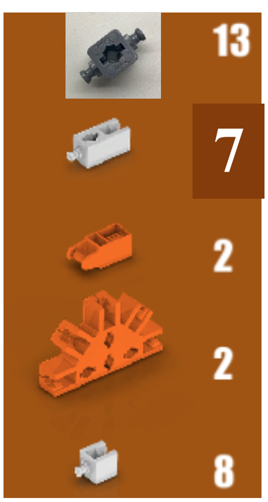
Activity Steps

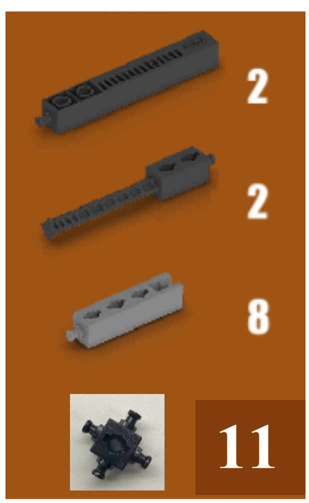
Have Scouts follow the procedure below in their Scout Notebook.

Materials

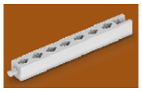
- 1 Engino® Newton’s Laws Kit—Inertia, Momentum, Kinetic & Potential Energy

1. Open the Engino kit. Unpack the pieces from the plastic bags. Try not to rip the bags too much—that way, you can still store pieces in them when they go back in the box.
2. Gather the following pieces for the inclined plane. It may be helpful to separate them into piles.





3. First, we will build part of the ramp (Model #1). Gather the following:

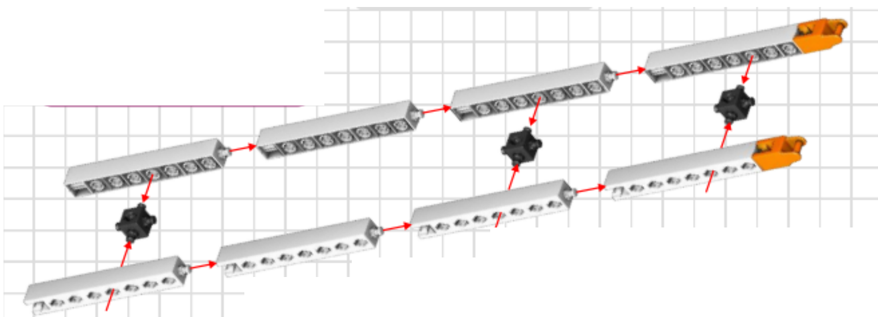
8 x  2 x  3 x 

4. Use the picture below for guidance. Snap four of the long, gray pieces together.
   - When snapping, be careful of your fingers!
   - Notice that pieces don't push together, but rather slide in and click.

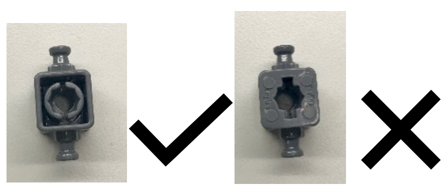
5. Add an orange piece to the end with the nub. Pay attention to how all the pieces go together!

6. Repeat this step with another set of four long, gray pieces and one orange piece.

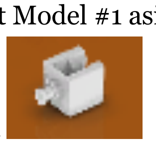
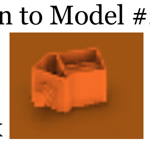
7. Add three black pieces at the locations shown in the picture below.



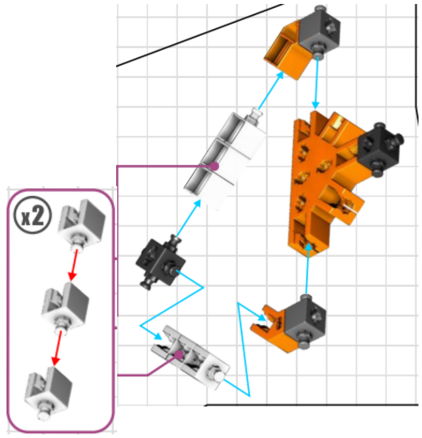
NOTE: When you are snapping pieces together, it is best to snap the nubs into the larger circular holes instead of the smaller side. See below:



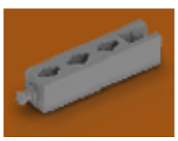
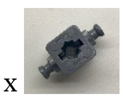
8. Put Model #1 aside and move on to Model #2! Gather the following materials:

6 x  2 x  2 x  2 x  1 x 

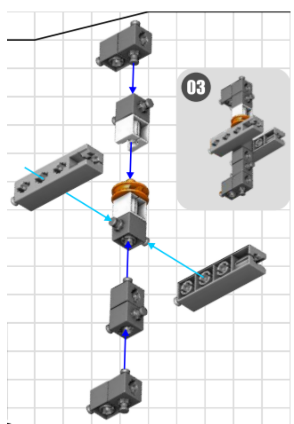
9. First, assemble two groups of three white blocks as seen below. Then, use these two groups to complete Model #2:



10. Next, gather these pieces:

2 x  1 x  2 x  8 x 

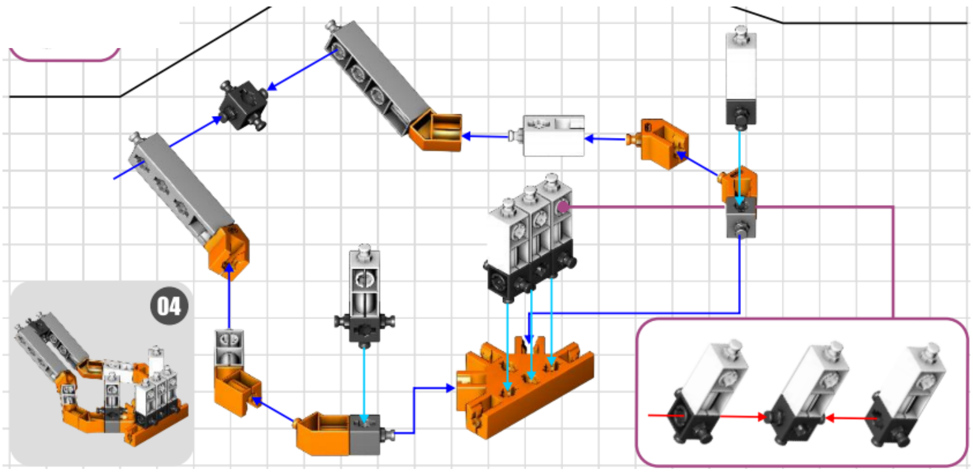
11. Assemble pieces for Model #3 to match the picture below. Start at the top and work your way down.

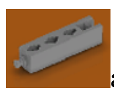


12. Now, on to Model #4! Gather the following pieces:

2 x  6 x  6 x  2 x  7 x  1 x 

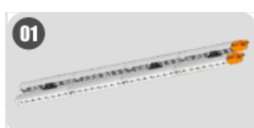
Now, assemble the base:



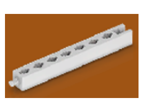
13. Notice that the two gray pieces  at the end are at an angle in the picture, pointed upward.

14. Pull the gray pieces upward, and the orange pieces attached to them will rotate accordingly. Make sure the rest of the base is sitting flat on the surface.

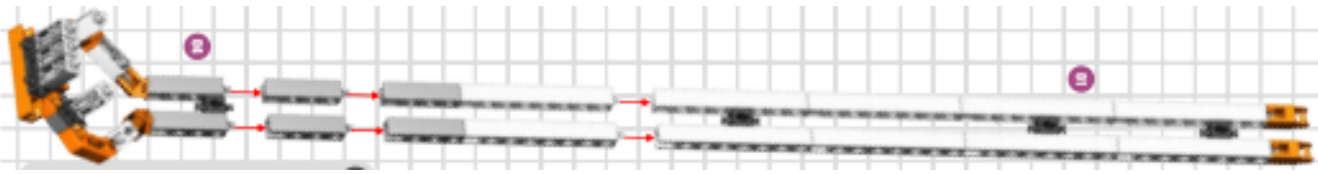
15. For Model #5, we will combine Model #1 and Model #4, so gather those two models now.



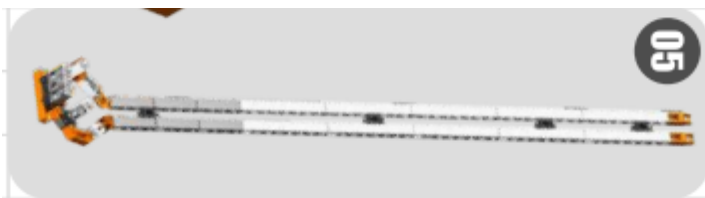
You'll also need two additional pieces:

4 x  2 x 

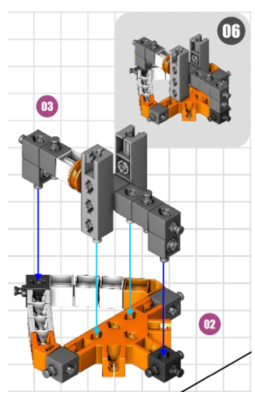
16. Attach Model #4 to those additional pieces and then attach it to Model #1, as seen in the picture below:



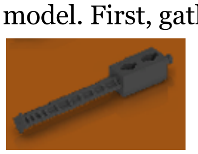
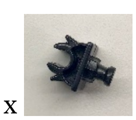
17. Model #5 should look like the picture below when complete. This is the ramp. But it won't be able to stand until we build its support. We will assemble that next!



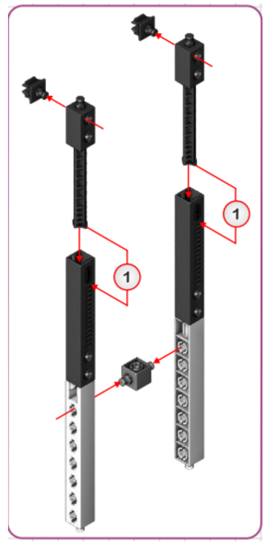
18. Combine Model #2 and Model #3 to make Model #6 as shown below. No additional pieces are needed in this step.



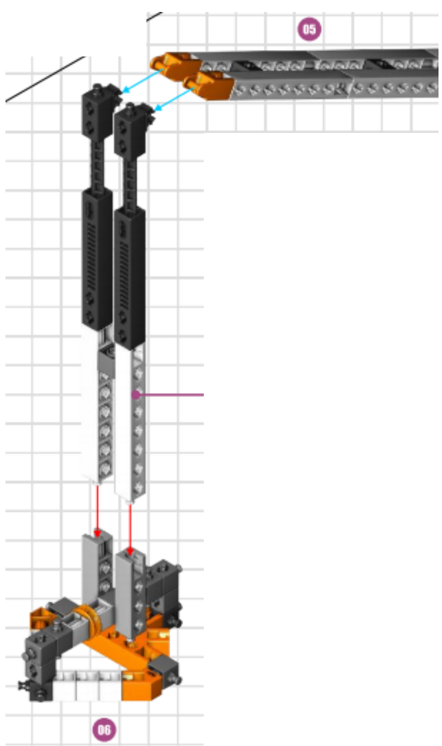
19. Now, on to the FINAL model. First, gather the following pieces:

2 x  2 x  2 x  1 x  2 x 

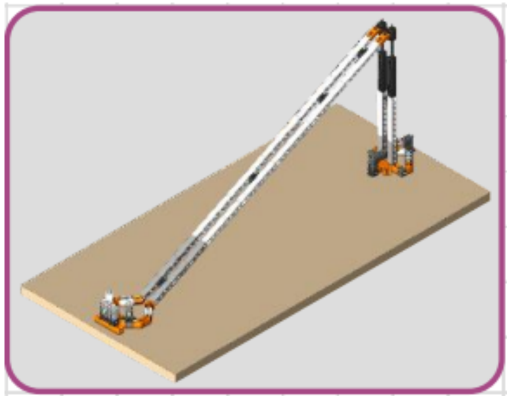
20. Assemble the pieces as shown in the picture below. Make sure you notch the skinny black piece into the first available space of the black rectangle. Then, turn the piece so that it clicks in.



21. Now, gather Model #6 and Model #5. Attach them to the pieces you just connected, as seen here:



22. Your final ramp should look like the picture below. You may need to do some adjusting in both base areas to make sure the ramp sits flat on the surface.



LEADER NOTE: Use the masking tape to make a small tag with each team's name on it so that they can identify their inclined plane at the next meeting.

Activity Adaptations for Scouts, as Needed

If Scouts finish early:

- Have them roll the golf ball down the inclined plane, and make observations and predictions for the tests in Meeting 2.

If Scouts are too challenged:

- Reassure them that they can finish building the model in the next meeting.
- Follow step-by-step as a Lab, walking through the activity together.

PART 5

Circle Up for Reflection Questions

- What were the challenges you faced and how did you get around them?
- If you could make any changes to your inclined plane, what would you do and why?
- Describe potential energy and kinetic energy. *(Potential energy is energy waiting to be released. Kinetic energy is the energy of an object related to its motion.)*
- What are Newton's three laws of motion? *(First law: An object that is at rest or moving at a constant speed in the same direction will stay that way until it is acted upon by another force. Second law: Acceleration—or, changing the movement of an object—depends on the mass of the object and the amount of force applied. Third law: For every action, there is an equal and opposite reaction.)*
- In the next meeting, we will be rolling items down the ramp and testing their speed!

PART 6

STEM Innovator Moment: Dr. Ivo Gough Eschrich

Physicists are scientists who use math, problem-solving skills, and a lot of initiative to study and analyze the world around us. They have a lot of curiosity and investigate our universe, the earth, and everything in it. Like Newton and his three laws of motion, physicists challenge themselves to explain phenomena by developing theories that offer explanations for big things like gravity, lasers, and energy, and small things like magnetic energy, particles, and atoms (electrons and protons)!

A physicist typically studies physics, mathematics, theory, and methodology. Today, a physicist can earn up to $115,000 a year.

Ivo Gough Eschrich worked at the University of California at Irvine for about 12 years and now works for Specialty Solar Solutions, a company that specializes in projects involving renewable energy. Dr. Eschrich believes that, "Participating in or conducting your own research is a great way to get some hands-on experience under your belt." (Sciencebuddies.org, 2019)

In this module, we will continue conducting our own experiments, and maybe you'll find that you want to become a physicist!

PART 7

Leaving It Better Than We Found It!

- Have Project Managers lead the others in cleaning up their work areas.
- Make any announcements for Scouts and/or parents.

Key Terms

- **GRAVITY:** *The force of attraction between objects that have mass—most often between the earth and other objects.*

- **POTENTIAL ENERGY:** *Energy waiting to be released (chemical, mechanical, or due to gravity).*

- **KINETIC ENERGY:** *The energy of an object due to its motion.*

- **INCLINED PLANE:** *A flat, supported surface tilted at an angle; also known as a ramp.*

- **NEWTON'S THREE LAWS OF MOTION:**

  1. *An object that is at rest or moving at a constant speed in the same direction will stay that way until it is acted upon by another force.*
  2. *Acceleration—or, changing the movement of an object—depends on the mass of the object and the amount of force applied.*
  3. *For every action, there is an equal and opposite reaction.*

MEETING PREVIEW AND SETUP

Meeting 2: Motion Madness—Part 2	**STEM Focus:** Physics and Math

After this meeting, Scouts will be able to

- Define and describe the three main properties of energy
- Analyze speed and calculate averages

Scout Law Character Focus
Kind

Total Meeting Time:

75–90 minutes

Opening (Pledge, Oath, Law):

10 minutes

Activity Introduction:

5–10 minutes

Safety Moment:

1–2 minutes

Activity:

45 minutes

Reflection:

5–10 minutes

STEM Innovator Moment:

2 minutes

Announcements/Cleanup:

5–10 minutes

Meeting Prep Time: 30 minutes

<u>Activity Prep</u>

- **Collect** supplies needed for meeting
- **Scout Notebook:** Meeting 2 (one per team)

<u>Space Needed</u>

Tables or a space for Scouts to test the inclined planes they built in Meeting 1, using various objects

<u>Teams of Three</u>

OPTIONAL: In each team, there will be three roles. Have Scouts get into teams and decide who will take each role **before the lesson begins**:

Project Manager (PM)—Gathers and manages all materials for the team. Oversees overall success of the project.

Principal Investigator (PI)—Leads observation and documents findings in the Scout Notebook.

Co-Principal Investigator (Co-PI)—Assists the PI and makes sure that everyone has a chance to participate.

Materials From Kit <u>Per Team</u>	**Materials Needed But NOT Included in Kit**
• 1 Engino® Newton's Laws Kit—Inertia, Momentum, Kinetic & Potential Energy • 1 inclined plane model from Meeting 1 • 1 stopwatch • 1 calculator • 1 marble • 1 golf ball • 1 ping-pong ball • 1 measuring tape • Masking tape	• N/A **Lab Leaders Optional Notes Section** *(This section is for YOU! List notes, reminders, and/or responsibilities and roles of the Scouts. You may also create a list of successes and challenges you experience during this activity and send it our way!)*

MEETING PLAN

Meeting 2: Motion Madness—Part 2	**STEM Focus:** Physics

Activity Overview

Scouts will explore the properties of energy and discover more about potential and kinetic energy. They will test the inclined plane they built in Meeting 1, conduct trials to analyze speed, and calculate averages.

PART 1

Introduction/Background Information

Use the questions and background information below to engage Scouts. *(Typical answers are in italics.)*

Break Scouts up into their teams of three before beginning the introduction.

- In this module, we will build on your knowledge of kinetic energy and potential energy. We'll introduce the three main properties of energy, and we'll learn how to analyze speed and calculate an average!
- To review, what is energy? *(The ability to do work. It is what makes things move or change! Energy is all around us, and it's what makes everything happen.)*
- Energy comes in two types. What are they? *(Potential energy and kinetic energy.)* What's the difference between the two types? *(Potential energy is energy that is stored and has the potential to do work. Kinetic energy is the energy of a moving object.)*
- Today, we are going observe potential energy and kinetic energy in motion. We will test how fast different items roll down our inclined plane. After testing, we are going to calculate the average speed of each item.
- Who remembers what *inertia* means? *(An object that is at rest will stay that way until it is acted on by another force.)*

Demonstrate inertia with a ping-pong ball and one of the assembled incline planes.

- *(Hold the ball at the top of the plane.)* Right now, the ball is at rest because I am holding it.
- But when I let go, another force will take over and act upon the ball. What force is that? *(Gravity.)*
- What will happen when I let the ball go? *(It will roll down.)*
- So, now I'm ready to drop the ball.
- This is inertia! (*The ball will stay at rest unless it is dropped—that's inertia. Once the ball is dropped, it will keep going until some external force acts upon it—that's inertia, too.)*

- Now, what is *speed*? Speed is how fast something travels in a given time. To calculate the speed of an object, divide the distance it travels by the time it takes to get there.

- Let's practice calculating speed before we test objects on our inclined plane. We are going to measure our distance in inches, and we'll measure our time in seconds.

  - **Materials for each team:** Masking tape, 1 measuring tape, 1 calculator, 1 golf ball, 1 marble, 1 ping-pong ball, 1 stopwatch

    1. Each team: Use the masking tape and measuring tape to create a start and a finish line on the floor, 3 feet apart from each other.

    2. Have one Scout from each team be the designated "timer" with the stopwatches.

    3. Have the remaining two Scouts on each team be the ones who gently roll the objects from the starting line (golf ball, marble, ping-pong ball).

    4. Each team: At the starting line, have the Scouts with the objects *gently* roll each object one at a time on the floor while the other Scout starts and stops the timer to see how long each object takes to reach the finish line (even though it may roll past).

    5. Each team: Next, have them log their distance (3 feet = 36 inches) and their time (in seconds) in the Scout Notebook on page 13 and calculate the speed of each object!

- Once your team has calculated the speed of the objects on your incline, you are going to calculate the average speed.

- What is an average? (*The calculated middle point or central value of a set of numbers.*) Does anyone know how to calculate it?

  - To calculate an average of something, you add up all of your numbers, then divide by how many numbers you had.

  - Today, we are going to find the average speed for each item. For example, if we tested three trial runs of an object going down a plane and the times were 2 seconds, 4 seconds, and 3 seconds, I would add all of these numbers together, which comes to 9.

  - To find the average, I would divide 9 by 3 because there were three trial runs. This will come to 3. So, 3 seconds is my average speed for that object.

- We are going to calculate the speed of each trial, and then the average speed of each object.

- Now, follow the steps in your Scout Notebook to test your inclined plane and calculate the average speed of your objects.

PART 2

Discuss the Scout Law Character Focus

Today we are focusing on the character point **Brave**.
What does it mean to be brave? *(To have courage.)*
How can we practice being brave today during our activities?

PART 3

Safety Moment

- Small pieces are included. Do not put any of them in your mouth!
- When snapping the pieces together, be careful to not hurt your fingers.
- When pulling the pieces apart, be gentle to avoid breaking them.

PART 4

Leader Note

- *Have the Scouts get back into their teams from the last meeting, and hand out the inclined plane models they built.*
- *If a team did not finish their model during Meeting 1, they can do so now.*

Activity Steps

Have Scouts follow the procedure below in their Scout Notebook.

Formula for speed:

Practicing Speed Calculations

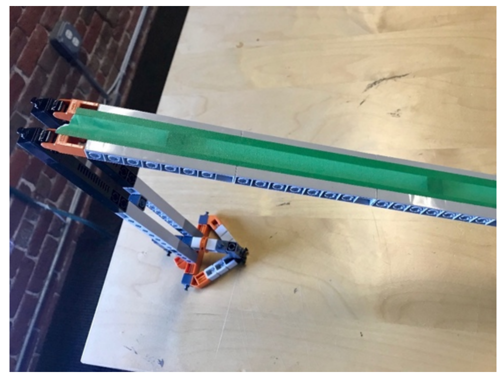
- Object tested: ______________________
- Time traveled: ______________________
- Distance traveled: ____________________

The **speed** of our object was:

If you did not finish your model from the last meeting, work with your team now to do so.

Activity Materials

- 1 Engino® Newton's Laws Kit—Inertia, Momentum, Kinetic & Potential Energy
- 1 inclined plane model from Meeting 1
- 1 marble
- 1 golf ball
- 1 ping-pong ball
- 1 measuring tape
- 1 stopwatch
- 1 calculator
- Masking tape



Part 1

1. Gather your three items to roll: golf ball, marble, and ping-pong ball.
2. Do a test run with the ping-pong ball.
3. Make any adjustments to ensure the ball rolls down the ramp into the base and doesn't fall off the ramp in mid-roll.
   - If needed, place a piece of masking tape down the whole ramp, as seen with the green tape on the right.
4. Before we begin, let's make some predictions!
   - Which object will roll down the ramp the fastest? Why?
   - Which object will roll down the ramp the slowest? Why?
5. Have one team member hold the golf ball at the top of the ramp, up against the black nubs.
6. Have another team member hold the stopwatch and count down, "three, two, one, go!"
7. On "go," the one holding the ball will let go and the one holding the stopwatch will time how long it takes the ball to reach the end of the ramp.
8. Conduct three trials with the golf ball and record the times in Table #1. Repeat with the marble and the ping-pong ball.

Table #1

Item	Trial #	Distance	Time	Speed	Average Speed
Golf ball	1				
	2				
	3				
Marble	1				
	2				
	3				
Ping-pong ball	1				
	2				
	3				

Calculating Speed

1. Measure the length of the inclined plane in inches. Write this in Table #1 above.
2. Use the calculator to calculate the speed of each object by dividing the length of the incline plane by the time on the stopwatch. Write these calculations in Table #1.

Calculating Average Speed

1. Use the calculator to calculate the average speed of each object.
   For the golf ball, add the speeds up from trials 1, 2, and 3. Then, divide by 3. Record this calculation in the table. Repeat for each item.

Circle up for discussion about your predictions and outcomes!

Part 2: Changing the Ramp Distance

1. Remove as many gray pieces as you want from the length of the ramp, but make sure the ramp still touches the ground or table.
2. Test your ramp to make sure it's steady. Make adjustments, as needed.
3. Measure your new ramp distance and write it in Table #2 below.
4. With the knowledge you have now, make new predictions!
   - Which item will roll down the new ramp the fastest? Why?

   ____

   - Which item will roll down the new ramp the slowest? Why?

   ____

5. Test each object three times!
6. Repeat the steps listed above under Calculating Speed and Calculating Average Speed. Write these calculations below in Table #2.

Table #2

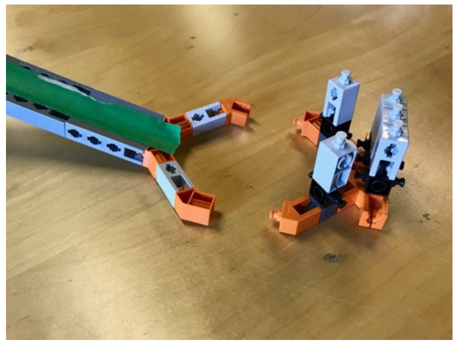
Item	Trial #	Distance	Time	Speed	Average Speed
Golf ball	**1**				
	2				
	3				
Marble	**1**				
	2				
	3				
Ping-pong ball	**1**				
	2				
	3				

Circle up for discussion about your predictions and outcomes!

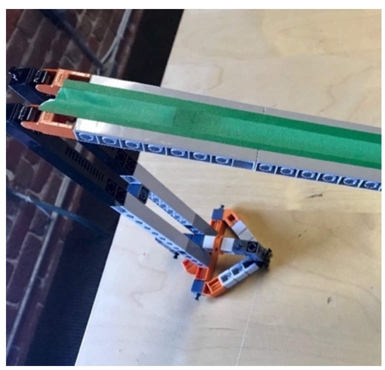
Part 3: A Friendly Competition (optional, if time allows)

The goal is to design a ramp and choose a ball that will roll down the ramp and reach the finish line first.

1. Pair up with another team.
2. Remove the bottom half of the end base from your ramp, as seen below. Put it to the side so it is not in the way. This will allow the ball to roll off the ramp and reach a finish line!



3. Decide what length you want your ramp to be.
   - Use the data you collected from Part 1 and Part 2 to help you determine what would be the best length.
4. Decide on which ball to use.
   - Use the data you collected to also inform your decision on which ball to use. Choose the ball you think will roll down your ramp the fastest and reach the finish line first!
5. Line up the front base of your ramp (see below) with the starting line. Make any needed adjustments to ensure your ramp is steady and ready to go!



6. Make sure a team member is ready to time how long it takes for your team's ball to reach the finish line.
7. Have your Lab Leader count down ("three, two, one, go!"), and let go of your ball at the top of your ramp at the same time as the other team.
   - Do not push the ball—let it roll.
8. Create your own table in the space provided below to input your object, trials, distance, time, speed, and average speed.
9. Repeat three times to collect three trials.
10. Now, calculate the speed and average speed.
11. Which team had the faster average speed? Is it the same team whose ball reached the finish line first?
12. What would you change to improve your experiment next time?

____

____

Table #3

Circle up for discussion about your predictions and outcomes!

Activity Adaptations for Scouts, as Needed

If Scouts finish early:

- Have them turn to page 21 in the instructional manual in the kit and complete exercises 1–5 of the quiz. Tell them to look back to pages 3–14 in the manual for background information.

If Scouts are too challenged:

- Have them only complete one trial for each object and disregard calculating the average speed.
- Follow step-by-step as a Lab, walking through the activity together.

PART 5

Circle Up for Reflection Questions

- Compare the average speed for all three items. What did you observe?
- Which object traveled the fastest? Why? *(The heaviest object, regardless of size.)*
- Which object traveled the slowest? Why? *(The lightest object, regardless of size.)*
- Were your predictions correct? Why or why not?
- If you could keep testing, what kind of object would you test next and how would you change your ramp? *(Example: Change the height.)*
- What are the three main properties of energy? *(Energy is conserved over time and can't be created or destroyed. Energy can be stored and transferred from one object to another through the interaction of forces between the objects. Energy comes in a variety of forms, and it can be converted from one form into another.)*
- Did you observe any of these properties with your experiment today? Describe what you observed. *(Your energy was used to place the ball at the top of the plane. Potential energy was stored in the ball, and when the ball was released, the potential energy was converted to kinetic energy as it rolled down the plane.)*

PART 6

STEM Innovator Moment: Dr. Lisa Randall

Dr. Lisa Randall, a professor at Harvard, investigates the relationship of physics to our universe. She is interested in asking questions like, what is the fundamental nature of gravity? And, what is the universe made of?

She is also interested in and conducts research on discovering extra dimensions. A dimension is a measurable extent of some kind—like the space around us and the directional movement of objects.

For example, the major dimensions that we know about are left/right, forward/backward, up/down, and time.

When Dr. Lisa Randall was asked how many dimensions she thinks there are, she replied, "I like to leave it as an open question. I like to say, 'What have we measured, what do we know?' and could there be other dimensions out there? And there certainly could be other dimensions out there!"

She goes on to say, "Is it really, truly that what we see is all that's there, or is it a case where we're just not physiologically designed to experience or see those dimensions, but we'll eventually find evidence of them."

Physics isn't just the study of moving objects. It can also mean the study of moving objects combined with WHERE they move—and whether other objects exist in dimensions that we can't even see!

Source:
www.physics.harvard.edu/people/facpages/randall
www.youtube.com/watch?v=QPyxNq_aHFg

PART 7

Leaving It Better Than We Found It!

- Disassemble your ramp, and put the pieces back in plastic bags in the box.
- You may not need all of the plastic bags. Discard any bags that aren't used.
- If you're having trouble pulling the pieces apart, attach longer pieces to give you leverage. Ask the Lab Leader for help if needed.
- Have Project Managers lead the others in cleaning up their work areas.
- Make any announcements for Scouts and/or parents.

Key Terms

- **SPEED:** *A distance of how far something travels in a given time.*

Formula:

speed = distance divided by time

$$\mathbf{s = d/t}$$

MEETING PREVIEW AND SETUP	
Meeting 3: Speed Machine	**STEM Focus:** Physics

After this meeting, Scouts will be able to

- Describe force and acceleration
- Calculate speed
- Understand the basics of physics and Newton's second law of motion

Scout Law Character Focus

Brave

Total Meeting Time

75–90 minutes

Opening (Pledge, Oath, Law):

10 minutes

Activity Introduction:

5–10 minutes

Safety Moment:

1–2 minutes

Activity:

45 minutes

Reflection:

5–10 minutes

STEM Innovator Moment:

2 minutes

Announcements/Cleanup:

5–10 minutes

Meeting Prep Time: 30 minutes

Activity Prep

- **Collect** supplies needed for meeting
- **Scout Notebook:** Meeting 3 (one per team)

Space Needed

Floor space for Scouts to design and build model

Teams of Three

OPTIONAL: In each team, there will be three roles. Have Scouts get into teams and decide who will take each role **before the lesson begins**:

Project Manager (PM)—Gathers and manages all materials for the team. Oversees overall success of the project.

Principal Investigator (PI)—Leads observation and documents findings in the Scout Notebook.

Co-Principal Investigator (Co-PI)—Assists the PI and makes sure that everyone has a chance to participate.

Materials From Kit <u>Per Team</u>	**Materials Needed But NOT Included in Kit**
• 2 manila folders • 4–5 feet of masking tape • 1 pair of scissors • 1 marble • 1 golf ball • 1 ping-pong ball • 1 measuring tape • 1 stopwatch • 1 calculator • 1 clear plastic cup • 1-foot string • 3 balloons	• N/A **Lab Leaders Optional Notes Section:** *(This section is for YOU! List notes, reminders, and/or responsibilities and roles of the Scouts. You may also create a list of successes and challenges you experience during this activity and send it our way!)*

MEETING PLAN	
Meeting 3: Speed Machine	**STEM Focus:** Physics

Activity Overview

Scouts will explore Newton's second law of motion to discover more about force and acceleration. Then, through creative collaboration, Scouts will design and engineer their own roller coaster out of various materials relying on gravity as their source of power and speed.

PART 1

Introduction/Background Information

Use the questions and background information below to engage Scouts. *(Typical answers are in italics.)*

Break Scouts up into teams of three before beginning the introduction.

- In this module, we will build on your knowledge of Newton's second law. We'll explore force and acceleration by building and testing a roller coaster!
- Now, who can tell me Newton's second law of motion? *(Acceleration—or, changing the movement of an object—depends on the mass of the object and the amount of force applied.)*
- This law involves two important concepts: force and acceleration. We will explore them further today! *(Use the key terms on page 55 as a visual reference for the Scouts.)*
- **Force** is any interaction that changes the motion of an object. When you push or pull a door open, you are applying a force! When you squeeze a can, you are applying a force. When you stretch a rubber band, you are applying a force. Who can think of another example? *(Any action that involves pushing or pulling on an object.)*
- **Acceleration** is the change in speed or direction of an object, from fast to slow or from slow to fast.
  - For example, when you first get on your bike and are not moving, you have a speed and acceleration of zero. But when you start to pedal and apply the force of your feet and legs, you power the pedals and begin to move, increasing in speed.
  - The amount of force you apply (or the faster you pedal), the more you increase your acceleration.
  - When you go down a hill, gravity is the force that is acting on your bike, and it will accelerate your speed—you'll start to go really fast!
- Force and acceleration are what Newton's second law is all about.

- Follow the steps in your Scout Notebook to do an experiment for Newton's second law. (This should take only five to seven minutes. The steps are listed below for Lab Leader reference.)

  – **Materials**: 1 balloon and 1 foot of string per Scout. Each Scout will:

    1. Blow up the balloon and tie it closed. Ask the Lab Leader for help if you need it!
    2. Tie one end of the string to the balloon tie.
    3. Grab the other end of the string and, in a circular motion, start to swing the balloon in circles.
    4. Try to get the balloon to go around, and around, and around.
    5. Slowly stop your motion.
       - What happened when you stopped the circular motion? ________________________________

- The direction of the balloon was constantly changing—going up, then going down, in circles. The circular movements of your hand applied force through the string to the balloon.

- The balloon's motion depended on the force of your circular movements. When force was no longer applied to the balloon, it slowly stopped, changing its speed.

- But why didn't the balloon keep going? The first law, inertia, states that an object in motion will stay in motion—unless what? Unless it is acted upon by another force, in this case, air resistance!

- Now, let's talk about roller coasters.

- How would you describe a roller coaster if you couldn't speak but could only use your arms? *(Scouts can use their arms to make crazy waves, ups and downs, or a steep slope like a drop.)*

- And how would you describe a roller coaster with your words? *(Ups and downs, fast, scary, slow at the beginning and then fast, steep drops and sharp turns.)*

- A roller coaster is mainly made up of its track and the train cars that people sit in.

- The thrill of a roller coaster comes not only from the loops, turns, and drops, but how FAST the train cars go. The speed of some roller coasters can almost reach 150 mph. For example, the roller coaster Formula Rossa in Abu Dhabi travels up to 149 mph!

- Some roller coasters are able to achieve high speed because they use motors and hydraulics to shoot the train cars in a given direction. But most roller coasters use a chain lift to pull the train car to the top of a hill and then let it drop down to achieve its speed.

- When a train car reaches the very top of the hill and starts to go down, it changes its speed, giving it acceleration.

- When the car is released at the top of the hill, the potential energy it has gained can be converted by the drop into kinetic energy, or speed. The car's acceleration will be dependent on the slope of the drop. The train car now might be going fast enough to finish the ride, or it may need to build up more energy with another drop or change in direction.

- The speed of the train car will vary throughout the ride as it goes through loops and turns and encounters friction. In some parts of the ride, there may be multiple drops so that the car can once again use the force of gravity to increase its speed and finish the ride!

- With the help of gravity, we are going to design a roller coaster that achieves high speed while also having places where the speed decreases.

- For our roller coaster activity, follow the steps in your Scout Notebook for the next **35–40 minutes**.

- After each team has built their roller coaster, we will test all of them to see if an object can land in the cup and also to calculate the speeds and see which coaster is the fastest!

PART 2

Discuss the Scout Law Character Focus

Today we are focusing on the character point **Kind**.
What does it mean to be kind? *(To be friendly and considerate to others.)*
How can we practice being kind today during our activities?

PART 3

Safety Moment

- Keep scissors on the table when they are not in use.
- Do not run, play, or point with scissors.

PART 4

Activity Steps

Have Scouts follow the procedure below in their Scout Notebook.

What is the definition of **force**?

____

____

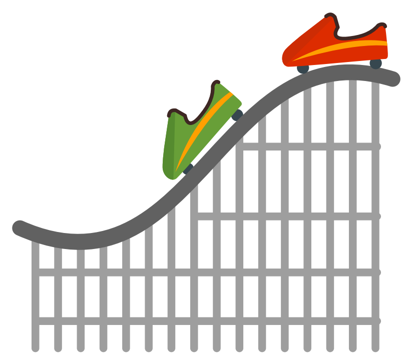
Acceleration is the change in speed of an object, from fast to slow or from slow to fast.

<u>Scout Roles</u>
Project Manager (PM)—Gathers and manages all the materials for the team. Oversees overall success of the project.
Principal Investigator (PI)—Leads observation and documents findings in the Scout Notebook.
Co-Principal Investigator (Co-PI)—Assists the PI and makes sure that everyone has a chance to participate.

REVIEW

Which car in this picture do you think has kinetic energy?

Which car do you think has potential energy?



Shutterstock.com—©IconBunny

<u>Roller Coaster</u>

Activity Objective

- *Create roller coaster track out of strips of manila folders for various objects to roll down and at the end, land in a cup without jumping out or falling over.*
- *Tape the start of the roller coaster to the top of a table, the wall, or the back of a chair.*

Coaster Requirements

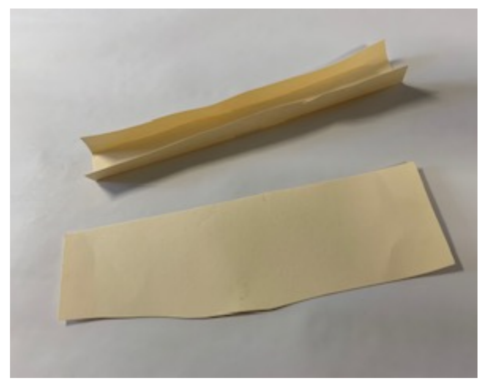
- At least 3 feet in length
- At least two drops
- Can only use the materials provided
- Marble, golf ball, and ping-pong ball must start at the beginning of the coaster

Materials

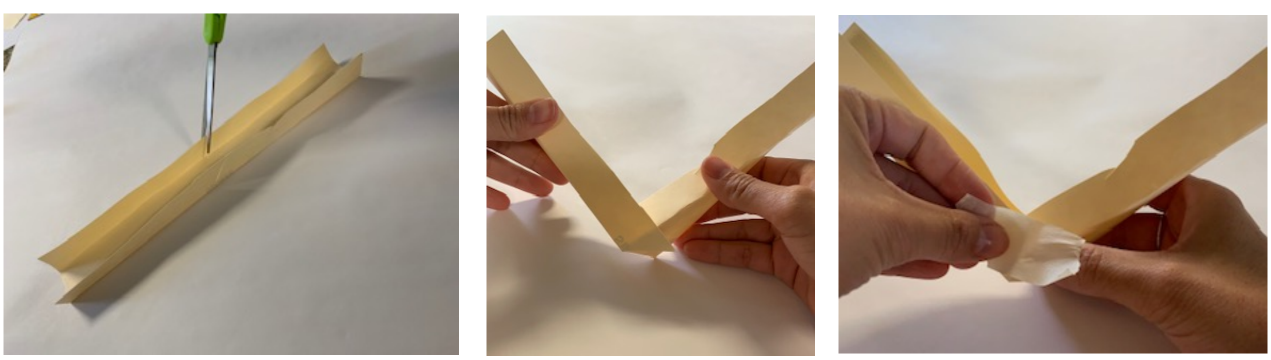
- 1 marble
- 1 golf ball
- 1 ping-pong ball
- 2 manila folders
- 4–5 feet of masking tape
- Measuring tape
- 1 pair of scissors
- 1 stopwatch
- 1 calculator
- 1 plastic cup (to catch the objects)

Track Basics

1. Cut out strips from your manila folders, each about 4 inches wide.
2. On each strip, fold the long edges up about 1 inch on each side to make the walls of the track.



3. To make a bend, cut one small slit down each side of the walls. Bend until you have reached the angle you desire, and use the tape to secure it.



4. To complete the track, tape all the strips together and create your coaster!

TIP: Get creative! You can also roll the strips into tubes and use the tape to secure them. Just make sure all of your objects can fit through the tubes!

Coaster Test

LEADER NOTE: *Facilitate the testing of the coasters one team at time. Before objects are rolled, have the team describe their design process, any challenges they faced during construction, and how they overcame these challenges.*

Your Lab Leader will have you test your coasters, one team at a time!

1. Name your coaster.
2. Make sure your cup is in place at the end of your coaster.
3. One at a time, let each object roll down your coaster to test for accuracy in landing in the cup and to time the speeds! Update the table below after each roll.

Item	In Cup?	Distance	Time	Speed
Golf ball				
Marble				
Ping-pong ball				

Reflection Questions

- Which object went the fastest?
- Why do you think that is?
- Out of all the teams, who had the fastest coaster for each object?

Activity Adaptations for Scouts, as Needed

If Scouts finish early:

- Have them make another 1- to 2-foot extension to their coaster, or see if they can add a turn.

If Scouts are too challenged:

- Have them start by making a simple, straight track with one drop instead of two.

PART 5

Circle Up for Reflection Questions

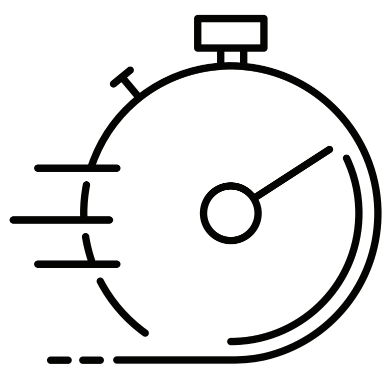
- What were the challenges you faced? How did you overcome them?
- At what points in your coaster did you see gravity increase the speed of your objects *(steep drops)*? Increasing speed is acceleration!
- Which of your objects went the fastest? *(This will vary depending on the coaster design. The heavier objects most likely went the fastest if the coaster had one drop. Scouts can do further experiments at home to test object mass and acceleration.)*
- This activity took a lot of patience, and to get through it, you had to just take one step at a time. It was important that you never gave up!
- Next time you are working on something hard, whether it's homework, a STEM activity, or a sport, remember to never give up trying! Practice being patient, and take one step at a time.

PART 6
STEM Innovator Moment: Alan Schilke
Alan Schilke is a structural engineer who specializes in designing roller coasters! He was the first to design and engineer a fourth-dimension roller coaster—one that allows the riders to move independently from the direction of the coaster. For example, the 2x coaster at Six Flags Magic Mountain is a fourth-dimension roller coaster engineered and designed by Schilke. *Schilke doesn't quite consider the designs of his roller coaster to be "beautiful art." For example, he says, think about crazy motorcycles. There are some motorcycles with crazy paint jobs, candy art, and even beautiful flames on them. And there are others that are not "fancy" at all. He considers his roller coasters to be like the motorcycles that are more industrial, with no fancy paint and hard steel, but have their own beauty to them!* *After designing a roller coaster, the most special days for Alan are the ones when he gets to ride it for the first time or when the coaster becomes open to the public. He says that the more he works and the harder he works, the more he WANTS to work!* *Interview Source: www.youtube.com/watch?v=0f5wb8sbEdY*
PART 7
Leaving It Better Than We Found It!
• Have Project Managers lead the others in cleaning up their work areas and throwing away the trash. • Recycle what you can! • Make any announcements for Scouts and/or parents.

Key Terms

- **FORCE:** *Any interaction that changes the motion of an object (speed or direction).*

- **ACCELERATION:** *The change in speed of an object, from fast to slow or from slow to fast.*



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MEETING PREVIEW AND SETUP

Meeting 4: Follow the Flow

STEM Focus: Electrical Engineering

After this meeting, Scouts will be able to

- Describe conductors and insulators
- Understand circuits and the flow of electric currents
- Design their own conductor and switches in a circuit

Scout Law Character Focus

Thrifty

Total Meeting Time

75–90 minutes

Opening (Pledge, Oath, Law):

10 minutes

Activity Introduction:

5–10 minutes

Safety Moment:

1–2 minutes

Activity:

45 minutes

Reflection:

5–10 minutes

STEM Innovator Moment:

2 minutes

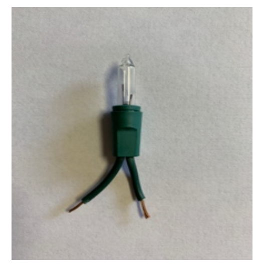
Announcements/Cleanup:

5–10 minutes

Meeting Prep Time: 30 minutes

Activity Prep

- **Collect** supplies needed for meeting
- **Scout Notebook:** Meeting 4 (one per team)
- **Precut and strip** the Christmas lights (at least 5 per team) as pictured at right:



- **Cut out** "parent/guardian notes" on page 71 to hand out to parents/guardians at end of meeting

Space Needed

Tables or a space for Scouts to design and build bridges

Teams of Three

OPTIONAL: In each team, there will be three roles. Have Scouts get into teams and decide who will take each role **before the lesson begins**:

Project Manager (PM)—Gathers and manages all materials for the team. Oversees overall success of the project.

Principal Investigator (PI)—Leads observation and documents findings in the Scout Notebook.

Co-Principal Investigator (Co-PI)—Assists the PI and makes sure that everyone has a chance to participate.

Materials From Kit <u>Per Team</u>	**Materials Needed But NOT Included in Kit**
• 5 sheets of foil • 1 pair of scissors • 5 Christmas lights • Clear tape • 5 paper clips • 2 9-volt batteries • 10 chenille stems • 2 feet of string • 3 manila folders • 5–6 craft sticks • 3 balloons	• N/A **Lab Leaders Optional Notes Section** *(This section is for YOU! List notes, reminders, and/or responsibilities and roles of the Scouts. You may also create a list of successes and challenges you experience during this activity and send it our way!)*

MEETING PLAN	
Meeting 4: Follow the Flow	**STEM Focus:** Electrical Engineering

Activity Overview

Scouts will explore Newton's third law of motion and understand the particles that make up an atom as they explore the flow of electric currents. They will also discover the difference between conductors and insulators as they design their own circuit out of various materials to light up Christmas lights using a 9-volt battery as their power source.

PART 1

Introduction/Background Information

Use the questions and background information below to engage Scouts. *(Typical answers are in italics.)*

Break Scouts up into teams of three before beginning the introduction.

- In this module, we will be exploring electric charges as we apply Newton's third law of motion.
- Who remembers what Newton's third law was? *(For every action, there is an equal and opposite reaction.)*
- This law involves the important concept of force. Who can remind us what a force is? *(Any interaction that changes the motion of an object, like a push or pull on a door, kicking a ball, pedaling a bike, etc.)*
- The forces caused by the interaction of two or more objects are called an action and a reaction. The force on the first object equals the force on the second object.

Newton's Third Law of Motion Demonstration

(Materials: 1 balloon per Scout)

1. In each team, one Scout will blow a little bit of air into a balloon to make it inflated but small, and hold it closed.
2. Another Scout will blow enough air into a balloon to make it medium-sized, and hold it closed.
3. A third Scout will blow enough air into a balloon to make it big, and hold it closed.
4. Ask the Scouts which balloon they think will fly around the room the longest.
5. On the count of three, have everyone let go of their balloons from the same point.

Reflection Questions

- Which balloon flew the longest, and why?
- The amount of air going into a balloon means that an equal amount will come out. When the air is released, a balloon generally flies in the opposite direction from the air, using the amount of energy that was put into it in the beginning. This is why some balloons fly in the air longer than others.
- This is Newton's third law of motion.

- With a battery-operated light, for example, the voltage from the battery runs through a path to a light bulb. The action is the electric voltage reaching the light. What is the reaction of the light?
- What if the battery has little to no charge? What will happen to the light? *(The light might be dim, or it won't turn on at all.)*
- What if the battery has a very high voltage and is fully charged? *(The light will be bright and fully lit.)*
- What exactly is electricity?
- The world is made up of matter, and matter is made up of **atoms**—microscopic pieces of matter, each with a positively charged center called the **nucleus** that is surrounded by negatively charged **electrons**. *(Use key terms on pages 67–69 as a visual reference for the Scouts.)*
- Every object is made up of atoms, and in most objects, the atoms' electrons don't move from one atom to another—they are secured to one atom. These objects are called **insulators**.
- For example, the electrons in the atoms of a piece of wood don't move around freely, which means the wood is an insulator. Most non-metallic objects are insulators.
- But, wait! Some objects have electrons that CAN move from one atom to another. This is because the electrons are just loosely bound to the atom. These objects are called **conductors**, and the electrons are able to flow freely from atom to atom, like a current in a river.
- Conductors are PERFECT objects for carrying an electric current! For example, copper wire is considered a conductor—the electrons are free to move through the copper like water in a pipe.

Exploring insulators and conductors: With the Scouts as a group, fill in the chart on page 71 of this guide and have everyone choose whether or not they think each item is a conductor or insulator.

Answer Key:

Steel	C
Silver	C
Rubber	I
Aluminum	C
Paper	I
Air	I

Bronze	C
Glass	I
Cotton	I
Lemon juice	C
Plastic	I
Wool	I

- Now, let's talk electricity! We know how it travels, but what is an electric current?
- The electric current starts with the power supply, which applies electric "force" called voltage to one end of the conductor, like a copper wire. When the current flows through a copper wire with enough "force" (voltage) and reaches a light bulb, the light bulb converts the power to light!

- An electric current is the flow of electrons—say, from a battery. This flow can only happen in an object that is considered a conductor when there is a power source and a place for the electrons to return. We call this closed electrical path a circuit.

- Voltage causes the loose electrons to flow from the negative side of the power supply to the positive side.
  - Imagine students packed in a tight hallway where only one of them can pass through at a time. Someone pushes the students at one end of the hall, and all the students start to move in one direction until they come out the other end. The electrons work like that!

- A **circuit** is a pathway for electricity to flow through a conductor from a power source—like our copper wire. If the circuit, or copper wire, has a break in it, the current cannot and will not flow. But sometimes a break in the circuit can be helpful!

- Can you think of an example of when you would want to stop the flow of electricity? *(Turning off a blender, turning a light or fan off.)*

- Using a switch, we are able to control the flow of the electricity in a circuit by stopping the flow with a break in the circuit.

- Think about a water hose. If we kink the hose, the water will stop flowing out and will sit in the hose. If we release the kink, the water will flow.

- This is the way a switch works. A switch can close a circuit so that electricity flows, or a switch can temporarily put a break in the circuit and stop the flow of electricity.

- Today, we are going to create our own electric current by using a battery as our power source and foil as our conductor. We will also experiment with switches!

PART 2

Discuss the Scout's Law Character Focus

Today we are focusing on the character point **Thrifty**.

What does it mean to be thrifty? *(To try not to be wasteful. Use time, food, supplies, and natural resources wisely.)*

How can we practice being thrifty today during our activities?

PART 3

Safety Moment

- Do NOT put the battery in or around your mouth; only use it as a power source for your circuit.
- Use the Christmas lights with CARE; do not break or play with the wires.
- Take your time when handling the lights and the battery.

PART 4

Activity Steps

Scouts will follow the procedures below in their Scout Notebook.

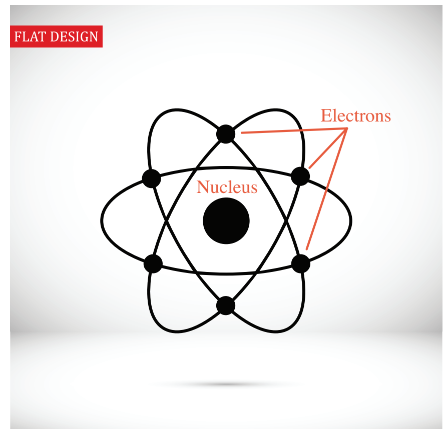
An **atom** is the smallest form of matter! It consists of a positively charged nucleus surrounded by negatively charged electrons (see picture below).

An **insulator** is an object that doesn't allow electrons to move from one atom to another.

What is an example of an **insulator**?

A **conductor** is an object that does allow electrons to move from one atom to another.

What is an example of a **conductor**?



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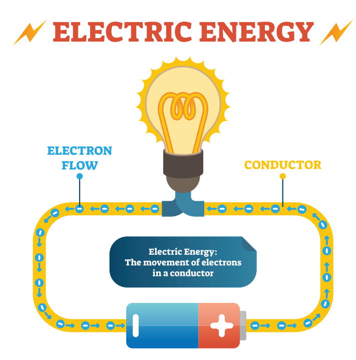
__Question:__ Which materials are acting as conductors, transferring the power from the 9-volt battery to the light bulb (Christmas light)?

Activity Materials

- 5 sheets of foil
- 1 pair of scissors
- 5 Christmas lights
- Clear tape
- 5 paper clips
- 2 9-volt batteries
- 10 chenille stems
- 2 feet of string
- 3 manila folders
- 5–6 craft sticks



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Procedure 1

1. Open your manila folders and cut them in half along the folded crease. You will use one side as the surface for your first circuit.
2. Cut three 2-inch strips of foil.
3. Cut 1 foot of string.
4. One at a time, you will test each material—the foil, the string, the craft sticks, and the chenille stems—to see which one works as a conductor.
5. With each material, create a circuit path on the construction paper leaving two small gaps—breaks—somewhere in the circuit path. Tape the circuit path in place.
6. Next, in one of the breaks, tape down a Christmas light to close the break so that the two wires of the light are touching separate ends of the circuit—closing and completing the circuit.
7. On the other break in the circuit, press the top of the 9-volt battery down so that it touches both ends of the circuit material.
8. Does your Christmas light come on? Why not?

REPEAT these steps using each material provided until you find a great conductor.

As you test each material, **DOCUMENT** your findings in the table below.
Did the material allow current to flow? Is it an insulator or a conductor?

Material	Current Flow (yes or no)	Insulator or Conductor?
Craft sticks		
Foil		
String		
Chenille stems		

Procedure 2

1. Using a conductor from your experiment, create another circuit that has three breaks. Use two Christmas lights and the battery.
2. Add a switch—a paper clip—to make a third break in your circuit path.
3. Stand your battery so that it stays on the circuit path. As a test, remove and then reinsert the paper clip in the break to see if it can turn the lights on and off.
4. List the materials you used: ____

DRAW your final circuit below and label the power source, conductor, and switches.

Activity Adaptations for Scouts, as Needed

If Scouts finish early:

- Have them create a long current using as many lights as they can (they may need to use two batteries).

If Scouts are too challenged:

- Have them use the foil to make their circuit instead of experimenting to find the correct conductor.

PART 5

Circle Up for Reflection Questions

- What was the most challenging part of this activity?
- How would you describe the difference between a conductor and an insulator?
- In life, it is important to spread kindness! Kindness lights up people's lives and can make a bad day into a GREAT day.
  - Can anyone share a time when someone was kind to them? How did it make you feel? *(Remember, this is a safe space for Scouts. Do not make anyone share if they don't want to. Instead, YOU can share!)*
  - Kindness is like electricity, and it is so important that we share it—we are conductors of kindness.
  - A lot of times, when you are kind to someone, it inspires them to be kind too. Kindness travels, just like a current in a circuit.
  - When we aren't kind to others, we are acting like insulators that don't allow goodness to flow.
  - Remember to be a conductor of kindness!

Announce the STEM Scout Challenge: Challenge the Scouts to share kindness three times before the next Lab. (Pass out notes to parents/guardians.)

PART 6
STEM Innovator Moment: Nikola Tesla

Has anyone heard about Tesla cars? A Tesla is an all-electric car—it doesn't need any gasoline! The engineers who founded Tesla in 2003 were determined to give the world an environmentally friendly car that was faster and better than cars that need gasoline.

Tesla cars were named after the well-known electrical engineer Nikola Tesla, who died in 1943. Sadly, in Tesla's lifetime, none of his projects and inventions ever received enough money to become something larger, but his work on the electric motor is considered the basis of electric motors today.

One of Tesla's dreams was that if anything needed electricity, it could get it from the air—similar to how we receive data today on our devices! With a passion for electricity, he dreamed BIG and was considered ahead of his time.

Tesla Inc. named their company after Nikola Tesla to honor his innovation and passion for electrical engineering.

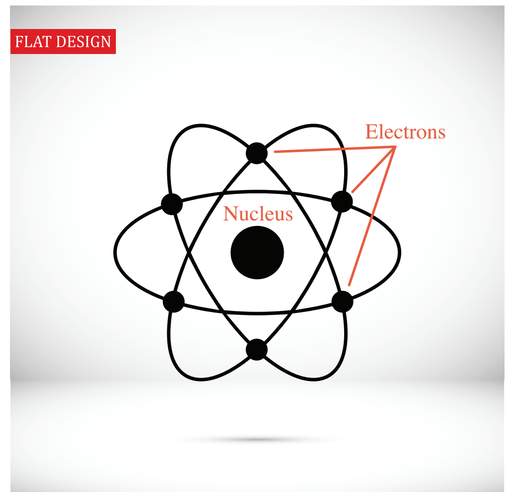
www.nytimes.com/2017/12/30/technology/nikola-tesla.html

PART 7
Leaving It Better Than We Found It!

- Have Project Managers lead the others in cleaning up their work areas and throwing away the trash.
- Recycle what you can!
- Make any announcements for Scouts and/or parents.

Key Terms

- **ATOM:** *The smallest form of matter—a positively charged nucleus surrounded by negatively charged electrons.*



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- **INSULATOR:** *A material with electrons that do not move from atom to atom and cannot carry an electric current.*

- **CONDUCTOR:** *A material with loosely bound electrons that can move from atom to atom and carry an electric current.*

- **CIRCUIT:** *A closed path or loop that electric current flows around. A circuit is usually made by linking electronic components together with wires.*

Conductor or Insulator?

OBJECT	CONDUCTOR (C) OR INSULATOR (I)?
Steel	
Silver	
Rubber	
Aluminum	
Paper	
Air	
Bronze	
Glass	
Cotton	
Lemon juice	
Plastic	
Wool	

Hi, Parent or Guardian! Your Scout has learned about electric currents and that there are some objects that can move an electric current (conductors) and some objects that can't (insulators). **STEM Scout Challenge:** Your Scout has been challenged to share kindness three times before the next Lab meeting and to be a "conductor of kindness." Happy Scouting!
Hi, Parent or Guardian! Your Scout has learned about electric currents and that there are some objects that can move an electric current (conductors) and some objects that can't (insulators). **STEM Scout Challenge:** Your Scout has been challenged to share kindness three times before the next Lab meeting and to be a "conductor of kindness." Happy Scouting!
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Hi, Parent or Guardian! Your Scout has learned about electric currents and that there are some objects that can move an electric current (conductors) and some objects that can't (insulators). **STEM Scout Challenge:** Your Scout has been challenged to share kindness three times before the next Lab meeting and to be a "conductor of kindness." Happy Scouting!
Hi, Parent or Guardian! Your Scout has learned about electric currents and that there are some objects that can move an electric current (conductors) and some objects that can't (insulators). **STEM Scout Challenge:** Your Scout has been challenged to share kindness three times before the next Lab meeting and to be a "conductor of kindness." Happy Scouting!

MEETING PREVIEW AND SETUP

Meeting 5: Fly, Saucer, Fly!	**STEM Focus:** Electrical Engineering

After this meeting, Scouts will be able to

- Describe a simple circuit
- Understand the effect a switch and load have on a circuit
- Build various simple circuits with switches and loads

Scout Law Character Focus

Trustworthy

Total Meeting Time

80–90 minutes

Opening (Pledge, Oath, Law):

10 minutes

Activity Introduction:

5–10 minutes

Safety Moment:

1–2 minutes

Activity:

45 minutes

Reflection:

5–10 minutes

STEM Innovator Moment:

2 minutes

Announcements/Cleanup:

5–10 minutes

Meeting Prep Time: 30 minutes

Activity Prep

- **Collect** supplies needed for meeting
- **Scout Notebook:** Meeting 5 (one per team)
- **Review** safety data sheets in portal for this lab

Space Needed

Tables or a space for Scouts to design and build circuits

Teams of Three

OPTIONAL: In each team, there will be three roles. Have Scouts get into teams and decide who will take each role **before the lesson begins**:

Project Manager (PM)—Gathers and manages all materials for the team. Oversees overall success of the project.

Principal Investigator (PI)—Leads observation and documents findings in the Scout Notebook.

Co-Principal Investigator (Co-PI)—Assists the PI and makes sure that everyone has a chance to participate.

Materials From Kit <u>Per Team</u>	**Materials Needed But NOT Included in Kit**
• Snap Circuits® Flying Saucer Plus Kit • 3 AA batteries • Markers • 1 pair of scissors • Tape	• N/A **Lab Leaders Optional Notes Section** *(This section is for YOU! List notes, reminders, and/or responsibilities and roles of the Scouts. You may also create a list of successes and challenges you experience during this activity and send it our way!)*

MEETING PLAN

Meeting 5: Fly, Saucer, Fly!	**STEM Focus:** Electrical Engineering

Activity Overview

Scouts will learn what a simple circuit is and how switches control the flow of the electric current. They will also explore how loads function in a circuit by building various circuits to fly the saucer, sound the horn, and light the lamp.

PART 1

Introduction/Background Information

Use the questions and background information below to engage Scouts. *(Typical answers are in italics.)*

Break Scouts up into teams of three before beginning the introduction.

- Before we begin, who completed our STEM Scout Challenge from the last meeting? The challenge was spread kindness three times. *(Have Scouts share.)*
- In this meeting, we are going to build on your knowledge of currents, circuits, and switches by learning about loads. In our test last week, the Christmas light was the load.
- To review, electricity is a type of energy that can build up in one place or flow from one place to another.
- Who remembers what current is? *(Electricity that moves from one place to another via a conductive path. It is made up of electrons that have an electric charge from a power source.)*
- For an electric current to happen, there must be a **circuit**. A circuit is a closed path or loop that electric current flows around. A circuit is usually made by linking electronic components together with wires. *(Use key terms on page 85 as a visual reference for the Scouts.)*
- Today we will be experimenting with **simple circuits**. A simple circuit has three components: a conductive path, a power source, and a load.
- Remembering from our last meeting, how can we control the flow of a current through a circuit? *(By using a switch.)*
- A simple circuit can have a switch to control the flow of current around the circuit.
- When you turn a switch on, electricity flows around the circuit. This is called a closed circuit.
- If you turn a switch off, what do you think happens to the flow of electricity? (*No electricity can flow*.) What type of circuit do you think this is called? (*Open circuit*.)
- A **load** is an electronic component that converts one form of energy into another form of energy when the current flows through it.

- Besides lights, can you think of other types of loads? (*Motor, horn/buzzer*.)

- A light bulb converts electrical energy into light and heat energy, and an electric motor converts electrical energy into mechanical energy and heat. What form of energy does a horn convert electrical energy into? (*Sound and heat*.)

- Any load will use some of the power available in its circuit, thus limiting the amount of power available to other components in the same path. If components are wired in parallel circuit, they do not affect the amount of power available to each other. We will learn about this in the next meeting.

- A **resistor** is a component that only converts electrical energy into heat.

Intro Activity (5–10 minutes)

1. Open the Snap Circuits® Flying Saucer Plus Kit.
2. Remove the pieces from the plastic bag.
3. Take two minutes to identify the parts labeled with an ID on page 36 in your Scout Notebook.

- Have Scout teams alternate to share their answers.

Answer Key

Object	ID
3-snap wire	3
Battery holder	B3
Press switch	S2
Motor	M1
Lamp	L4
Horn	W1

After parts with IDs are labeled, examine the other pieces.

- Ask the Scouts what other parts are in the kit. (*Base grid, glow fan, swirl pattern on cardboard, prismatic film/shiny paper*.)

Have students observe the clear base grid and recognize the numbers and letters for placement purposes.

- Today, we are going to build our own simple circuits with switches and loads, and experiment with the motor and fan, the horn, and the lamp.

PART 2

Discuss the Scout’s Law Character Focus

Today we are focusing on the character point **Trustworthy**.
What does it mean to be trustworthy? *(That people can rely on you to be honest or truthful.)*
How can we practice being trustworthy today during our activities?

PART 3

Safety Moment

- Do not put a battery in or around your mouth. Only use it as a power source for your circuit.
- Do not touch the motor or fan during operation.
- Do not lean over the motor. Do not launch or throw the fan at people.
- Always check the wiring before turning on the circuit. Never leave the circuit unattended while it is on.
- Do not mix old and new batteries.
- Never place a component directly over the battery holder (see illustration at right).

PART 4

Activity Steps

*Scouts will follow the procedures below in their Scout Notebook***.**

There are two procedures. After each one, circle up the Scouts to talk about what they examined and why.

A simple **circuit** is a closed path or loop that electric current flows around, including a source of power, a conductive path, and a load. The circuit can also have a switch.

What is a **switch**?

____

____

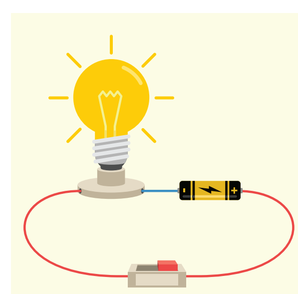
What is an example of a **load**?

____

____

Materials

- Snap Circuits® Flying Saucer Plus Kit
  - 1 three-snap wire
  - Battery holder
  - Press switch
  - Motor
  - Fan
  - Lamp
  - Horn
  - Clear base grid
- 3 AA batteries



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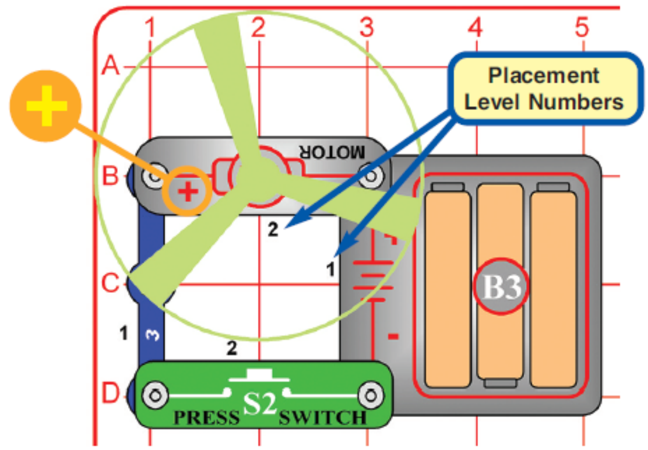
Procedure 1



1. Install 3 AA batteries into the battery holder (B3).

2. Build the circuit shown on the right on the clear base grid. Pay attention to the placement on the grid and the orientation of the parts.

3. Place all the parts with a black **1** next to them (see diagram) on the clear base grid first.

4. Assemble parts marked with a **2**.

5. Place the fan on the motor (M1).

6. **Press** the switch (S2). What happens to the motor and fan? Why?
   ____
   ____

7. When the motor has reached maximum speed, **release** the switch. As you release, make sure you are not leaning over the fan. What happens? Why?____
   ____

8. Retrieve the fan. Reverse the motor so that the + side goes to the + side of the battery holder.

9. Place the fan on the motor and **press** the switch.
   What happens? Why?____
   ____ Put your hand over the fan. What do you feel? __________________________
   ____

10. **Release** the switch. What happens? Why?
    ____
    ____

11. Disassemble the circuit.

CIRCLE UP for Procedure 1 Discussion

- When we reversed the motor, what happened? Why?
- Instead of the air being blown down through the blades and the fan releasing into the air, the fan stays on the motor and blows air up and away from the motor, like an electric fan in your home.

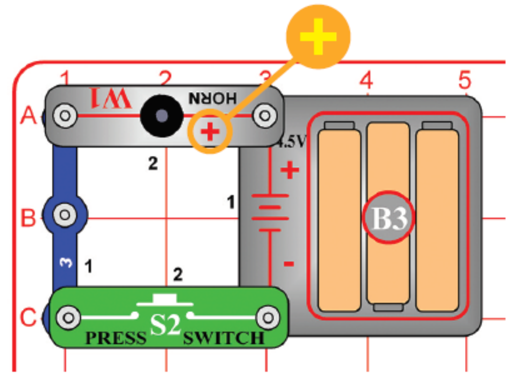
Procedure 2

1. Build the circuit shown here on the clear base grid. Pay attention to the placement on the grid and the orientation of the parts.
2. Place all the parts with a black **1** next to them (see diagram at right) on the clear base grid first.
3. Assemble parts marked with a **2**.
4. **Push** the switch (S2). What happens? Why?

   ____

5. **Release** the switch. What happens? Why?

   ____



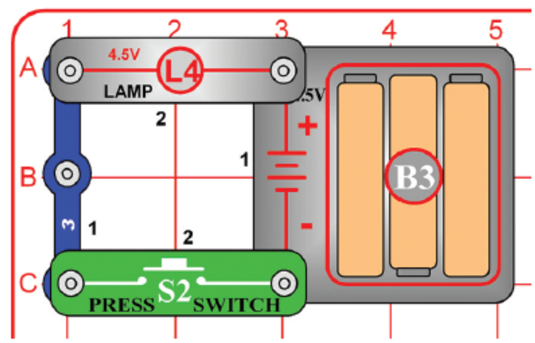
6. Remove the horn (W1) from the grid. Place the lamp (L4) as shown in the diagram below.
7. **Push** the switch. What happens? Why?

   ____

8. **Release** the switch. What happens? Why?

   ____

9. Disassemble the circuit.



CIRCLE UP for Procedure 2 Discussion

- What did you notice about pressing and releasing the switch with the horn and lamp?
- Pressing the switch sounded the horn and turned on the light. Releasing the switch turned off the horn and the light. The switch controlled the flow of the current around the circuit.

Activity Adaptations for Scouts, as Needed

If Scouts finish early:

- Have them proceed to Project #8 in the kit manual. If this is completed, allow them to also experiment with Projects #3 and #4 in the manual. For those two projects, they will need paper, scissors, tape, and different color markers.

If Scouts are too challenged:

- Have them focus on Procedure 1 (Projects #1 and #2 in the manual).

PART 5

Circle Up for Reflection Questions

- What was the most challenging part of this activity?

- To review, what is a simple circuit? *(A closed path or loop that electric current flows around. It includes a source of power, a conductive path, and a load, and it can also have a switch.)*

- What is bullying? *(Bullying is repetitive, unwanted, aggressive behavior that involves a power imbalance.)*

- What is cyberbullying? *(Cyberbullying is bullying that takes place over digital devices like cell phones, computers, and tablets.)*
    - Cyberbullying can occur through texting, apps, social media, forums, or gaming where people can view, participate in, or share content. It includes sending, posting, or sharing negative, harmful, false, or mean content about someone else.

    - If you noticed someone bullying or cyberbullying someone else, how could you intervene safely? *(Take a stand by offering support to the person being bullied, and get an adult that you trust involved.)* If you don't say or do anything, the bully will think it is OK to keep treating others that way. If bullying is allowed to continue, it can get very dangerous.

    - By interrupting the bully's "flow," what component of a circuit are you acting like? Why? (*A switch, because you are stopping the bully's bad behavior just as a switch can turn off the current.)*

    - Remember to be kind to everyone, and if you notice bullying or cyberbullying, safely intervene by offering support to the person being bullied and involving an adult you trust.

PART 6

STEM Innovator Moment: Vijay Ramani

In the U.S., the transportation industry is the largest energy consumer. But with the world looking for ways to make energy that is clean, large forms of transportation like planes and ships make it quite a challenge.

We've seen electric cars, and homes powered by solar energy. However, when it comes to the larger forms of transportation, it's harder to use a clean energy source because of the amount of power and energy they require to run.

Vijay Ramani, a professor of Environment and Energy at Washington University in St. Louis, Missouri, might have found a way around this challenge!

Dr. Ramani is leading a team of engineers in developing a high-power fuel cell that can produce twice the amount of voltage as the fuel cells we use today. Potentially, this high-power fuel cell could be used to power planes, ships, and other large forms of transportation, which would decrease the amount of oil use.

They call this development "pH-gradient-enabled microscale bipolar interface," or PMBI for short. PMBI uses membrane technology and is thinner than a strand of human hair!

Can you imagine flying in an airplane that doesn't use fuel but, instead, a battery?

With parent or guardian permission, Scouts can watch Dr. Yushan Yan's TEDxUD talk on YouTube at home for more detailed information:

***Title:** "Reinventing the fuel cell: Dr. Yushan Yan at TEDxUD"*
www.youtube.com/watch?v=80wub4HxvhM

Source: www.sciencedaily.com/releases/2019/02/190225123459.htm

PART 7

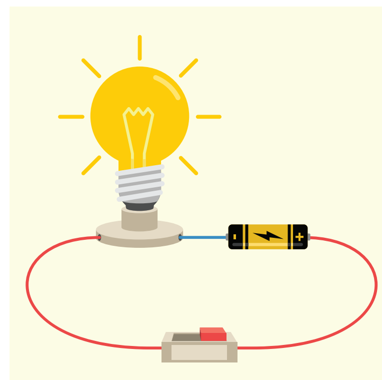
Leaving It Better Than We Found It!

- Remove the batteries from the battery holder.
- Have Project Managers lead the others in cleaning up their work areas and putting the pieces back in the kit.
- Make any announcements for Scouts and/or parents.

Key Terms

- **SIMPLE CIRCUIT:** *A closed path or loop that electric current flows around. The circuit includes a source of power, a conductive path, and a load. It can also have a switch.*

- **SWITCH:** *An electronic component that controls the flow of the current.*



Shutterstock.com—©yusufdemirci

- **LOAD:** *A device that converts electrical energy into another form of energy (such as a light bulb).*

<table>
<tr><th colspan="2">MEETING PREVIEW AND SETUP</th></tr>
<tr><td>Meeting 6: Working Together in Series</td><td>STEM Focus: Electrical Engineering</td></tr>
<tr><td colspan="2">After this meeting, Scouts will be able to
Describe and distinguish between a series circuit and a parallel circuit
Combine a series circuit and a parallel circuit to make a combination circuit
Build various types of circuits with switches and loads</td></tr>
<tr><td colspan="2">Scout Law Character Focus
Cheerful</td></tr>
<tr><td>Total Meeting Time

80–90 minutes

Opening (Pledge, Oath, Law):

10 minutes

Activity Introduction:

5–10 minutes

Safety Moment:

1–2 minutes

Activity:

45 minutes

Reflection:

5–10 minutes

STEM Innovator Moment:

2 minutes

Announcements/Cleanup:

5–10 minutes</td><td>Meeting Prep Time: 30 minutes

<u>Activity Prep</u>
Collect supplies needed for meeting
Scout Notebook: Meeting 6 (one per team)
Review safety data sheets in portal for this lab
<u>Space Needed</u>
Tables or a space for Scouts to design and build circuits

<u>Teams of Three</u>
OPTIONAL: In each team, there will be three roles. Have Scouts get into teams and decide who does each role before the lesson begins:

Project Manager—Gathers and manages all materials for the team. Oversees overall success of the project.

Principal Investigator—Leads observation and documents findings in the Scout Notebook.

Co-Principal Investigator—Assists Principal Investigator and makes sure that everyone has a chance to participate.</td></tr>
</table>

Materials From Kit Per Team	**Materials Needed But NOT Included in Kit**
• Snap Circuits® Flying Saucer Plus Kit • 3 AA batteries	• N/A
	Lab Leaders Optional Notes Section *(This section is for YOU! List notes, reminders, and/or responsibilities and roles of the Scouts. You may also create a list of successes and challenges you experience during this activity and send it our way!)*

MEETING PLAN	
Meeting 6: Working Together in Series	**STEM Focus:** Electrical Engineering

Activity Overview

Scouts will learn what parallel, series, and combination circuits are and how they differ from one another. They will build each type of circuit using switches and various loads.

PART 1

Introduction/Background Information

Use the questions and background information below to engage Scouts. *(Typical answers are in italics.)*

Break Scouts up into teams of three before beginning the introduction.

- In this meeting, we are going to build on your knowledge of currents, switches, and loads, and introduce three different types of circuits: parallel, series, and combination.
- To review, what is electric current? *(Electricity that moves from one place to another via a conductive path. It is made up of electrons that have an electric charge from a power source.)*
- What is a circuit, and what components make up a simple circuit? *(A circuit is a closed path or loop that electric current flows around. A simple circuit is made by linking electronic components including a conductive path, a power source, a load, and sometimes a switch.)*
- What does a switch do in a circuit? *(A switch can be used to control the flow of the current in a circuit.)*
- What is a load in a circuit? Give some examples. *(A load is an electronic component that turns on when the current flows through it, converting electrical energy to another form of energy. Loads include light bulbs, buzzers/horns, and motors).*
- A **series circuit** has more than one load but only one path through which the electricity flows. The current moves along the single path with no branches, through each load—one after the other. *(Use the key terms on pages 97–99 as a visual reference for the Scouts.)*
- Since the total current flows through the circuit, the components are sharing the power of the battery. If you have a lot of light bulbs, for example, the overall light will be dim because the bulbs are sharing the same power source.
- If one load or component is damaged in a series circuit, the entire circuit will not function. For example, if one light bulb goes out, then all of the lights will not work because the path of electricity is cut off. Think about Christmas lights: In some older Christmas light strands, if one bulb goes out, the whole strand of lights won't light up!

- A **parallel circuit** also has more than one load, but they are arranged on more than one path. The electricity flows from the power source through many branches. The power source is connected directly across each load in a parallel circuit. Each load "sees" the whole power supply voltage.

- The full power supply voltage goes to each component in a parallel circuit. For example, if there are a lot of lights in a parallel circuit, they won't be dim like those in a series circuit because each component is receiving the full voltage of the power source.

- If one load or component is damaged in a parallel circuit, it will not affect the other loads in the circuit. This is because the electricity is not flowing through a single path. Consider the lights in a kitchen or a classroom. If one bulb goes out, all of the other lights stay on because they aren't affected.

- A **combination circuit** is one that has a combination of series and parallel paths for the electricity to flow through. The properties of this circuit are a combination of the properties of series and parallel circuits.

- Today we are going to build our own parallel, series, and combination circuits with switches and loads.

PART 2

Discuss the Scout's Law Character Focus

Today we are focusing on the character point **Cheerful**.
What does it mean to be cheerful? *(To feel or show happiness.)*
How can we practice being cheerful today during our activities?

PART 3

Safety Moment

- Do not put a battery in or around your mouth. Only use it as a power source for your circuit.
- Do not touch the motor or fan during operation.
- Do not lean over the motor. Do not launch or throw the fan at people.
- Always check the wiring before turning on the circuit. Never leave the circuit unattended while it is on.
- Do not mix old and new batteries.
- Never place a component directly over the battery holder (see illustration at right).

PART 4

Activity Steps

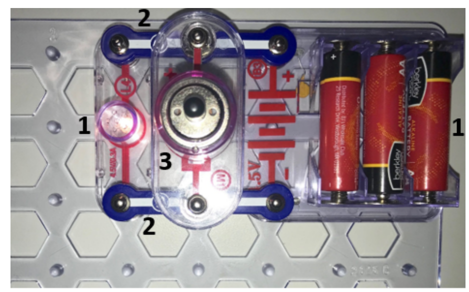
Scouts will follow the procedures below in their Scout Notebook.

Materials

- Snap Circuits® Flying Saucer Plus Kit: 3 three-snap wires, battery holder, switch, motor, fan, lamp, horn, clear base grid
- 3 AA batteries

Procedure 1a

1. Install the three AA batteries into the battery holder (B3). Make sure the + and – sides of the batteries match the + and – marks on the battery holder.



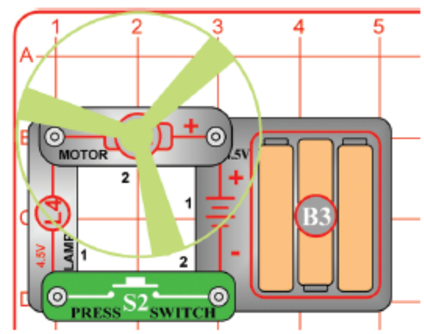
2. Build the circuit shown here on the clear base grid. Pay attention to the placement on the grid and the orientation of the parts.
3. Place all the parts with a black **1** next to them (see photo) on the clear base grid first.
4. Assemble the parts marked with a **2**.
5. Before you assemble the parts marked with a **3**, what should you notice about the lamp (L4)? ____
6. Now, assemble the parts marked with a **3**. Note that the motor (M1) does not have the fan on it. When placing the motor on the circuit, make sure your hand is away from the black piece on top.
7. What happens to the lamp and the motor? Why? ____
8. Remove the motor from the circuit. Be careful of the spinning top. What happens to the lamp? Why?

   ____
9. Is this circuit a **series**, **parallel**, or **combination** circuit? Circle your answer.

LEADER NOTE: After everyone completes Procedure 1a, circle up to discuss the following:

- Which answer did you circle for #9?
- Describe why you think it is that type of circuit. *(It's a parallel circuit because the loads are arranged on separate paths; the full voltage is provided to each of these paths.)*
  - The motor and the lamp both received full power. Neither one was weakened because they weren't sharing power like in a series circuit.
  - When we removed the motor, the lamp still worked. In a parallel circuit, if one load is damaged, it will not affect the other loads because the current isn't flowing through a single path.
- Have students disassemble the circuit.

Procedure 1b



1. Build the circuit shown here on the clear base grid. Pay attention to the placement on the grid and the orientation of the parts.
2. Place all the parts with a black **1** next to them on the clear base grid first.
3. Assemble the parts marked with a **2**.
4. Place the fan on the motor (M1).
5. **Press** the switch (S2). What happens to the motor and the fan?

   ____

   Watch the lamp (L4) closely. What do you notice? Why does this happen?

   ____

6. **Release** the switch. Hold a finger on the center of the fan to prevent it from spinning. Be careful not to put your finger in the blades.
7. Now, press the switch with a different hand. What happens to the lamp? Why?

   ____

8. While pressing the switch, ease your finger off the fan. What happens to the lamp? Why?

   ____

9. Remove the motor and the fan from the circuit. Press the switch. What happens to the lamp? Why?

   ____

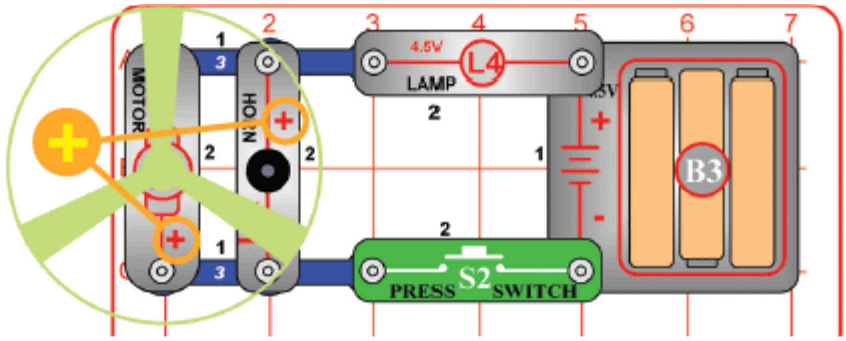
10. Is this circuit a **series**, **parallel**, or **combination** circuit? Circle your answer.

LEADER NOTE: After everyone completes Procedure 1b, circle up to discuss the following:

- Which answer did you circle for #10?
- Describe why you think it is that type of circuit. *(It's a series circuit because the total current flowed through each part of the circuit.)*
  - When we removed the motor, the lamp no longer worked. That's because there is only one path for the current in a series circuit, and now the circuit is open.
  - The components also share the power, as shown by the dim lamp.
- Have students disassemble the circuit.

Procedure 2

1. Build the circuit shown below on the clear base grid. Pay attention to the placement on the grid and the orientation of the parts.
2. Place all the parts with a black **1** next to them on the clear base grid first.
3. Assemble the parts marked with a **2**.
4. Place the fan on the motor (M1).
5. **Press** the switch (S2). What happens to the lamp (L4), the horn (W1), and the motor? Why?



____

____

6. **Release** the switch.
7. **Compare** the performance of the lamp and the horn and the height of the fan to previous circuits you've made. What do you notice is different this time? Why?

   ____

8. **Swap** the locations of the lamp and the motor. Orientation doesn't matter.
9. **Press** the switch. Observe and compare the performance of the lamp to the previous setup. **Release** the switch.
10. Is this circuit a **series**, **parallel**, or **combination** circuit? Circle your answer.

LEADER NOTE: After everyone completes Procedure 2, circle up to discuss the following. Then move on to the final group reflection.

- Which answer did you circle for #10?
- Describe why you think it is that type of circuit. *(It's a combination circuit because it has a combination of series and parallel paths for the electricity to flow through.)*
  - The horn and the motor are parallel to each another, and they are in series with the lamp and the switch.
  - All of the current flows first through the lamp, then the motor and the horn, then back through the switch. The power is shared between the components, making them weaker.
- Have students disassemble the circuit.

Activity Adaptations for Scouts, as Needed

If Scouts finish early:

- Have them proceed to Projects #9 and #11 in the kit manual.

If Scouts are too challenged:

- Have them focus on parallel circuits (not in the kit manual) and series circuits (Projects #12 and #13 in the manual).

PART 5

Circle Up for Reflection Questions

- What was the most challenging part of this activity?

- What are the differences between a parallel circuit and a series circuit?

- In school and at other times in life, you need to work with others—sometimes with a lot of people in a group setting.

- Can someone share a time when they worked together with someone on a project? How did you split up the tasks? *(Remember, this is a safe space for Scouts. Do not make anyone share if they don't want to. Instead, YOU can share!)*

  - Depending on the project, the group members may work in parallel or series—or a combination of the two—like a circuit!

  - Working in **parallel** means each person is doing something different, but all at the same time. For example, if everyone in your family is cleaning the house together, each person will have a different chore to do. If one person stops doing their chore, that doesn't mean everyone else has to stop.

  - Working in **series** means everyone plans and executes the project together. To continue the previous example, everyone might share each chore. They could first work on cleaning the kitchen together, then the bathrooms, and so on. But if someone stops helping when they haven't finished cleaning a room, they can't move on to the next one.

- In both cases, the project will be completed one way or another, but the path to completion is different. It's just like a parallel circuit having many different paths for the current to flow through at the same time and a series circuit having only one path.

- In school and in life, it is important to learn how to collaborate with others!

PART 6

STEM Innovator Moment: Katy Deacon

Katy Deacon got her start in engineering when she was part of an extracurricular engineering program in college. Her classmates and professor met one night a week for a year (like STEM Scouts!) and worked together on a project to reduce the amount of heat loss in buildings.

This was her first experience in engineering, and she noticed that it came easy to her, whereas writing essays did not.

Since receiving her master's degree in electrical engineering, Deacon has focused on energy conservation. She spends a lot of her time in project management, overseeing the execution of the various projects that she designs—like solar-powered schools and wind turbines.

In 2007, Deacon was named the Young Woman Engineer of the Year, and in an interview shortly after that happened, she said, "When you are an engineer, you are a part of a team of people who work together. Whether you are a woman or a man, you share your different skills to create the solution for the client."

She went on to say, "I think we need to open up those boundaries and show young people that it's possible to do things other than the stereotypes."

Katy Deacon loves solving problems for people, especially saving energy and generating renewable energy to make our world's energy sustainable and more efficient!

Source: www.independent.co.uk/student/magazines/interview-katy-deacon-young-woman-engineer-of-the-year-448814.html

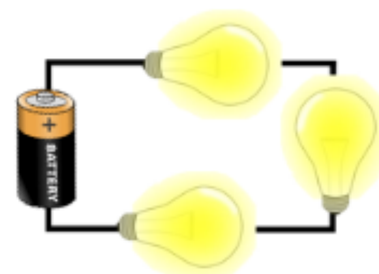
PART 7

Leaving It Better Than We Found It!

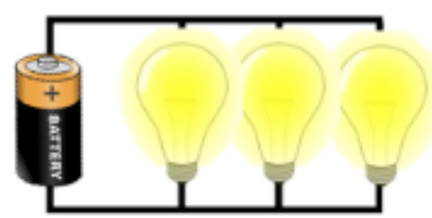
- Remove the batteries from the battery holder.
- Have Project Managers lead the others in cleaning up their work areas and putting the pieces back in the kit.
- Make any announcements for Scouts and/or parents.

Key Terms

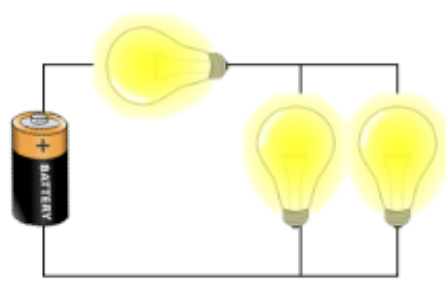
- **SERIES CIRCUIT:** *A circuit in which all of the current flows in a single path through each part of the circuit. Components share the power.*



- **PARALLEL CIRCUIT:** *A circuit in which the current is divided into separate paths. Each component receives full power.*



- **COMBINATION CIRCUIT:** *A circuit with a combination of series paths and parallel paths through which the electricity flows.*



Boy Scouts of America
STEM Scout Module Survey, 2019

iPhone/iPad Directions:

1. Open the Camera app on the iPhone or iPad.
2. Make sure you have adequate lighting so the camera can pick up the QR code.
3. Align the camera with the QR code.
4. The camera will read the QR code and provide you with a notification to access whatever it contains.

Android Instructions:

1. Tap the Navigation (three stripes on the upper left corner).
2. Choose: Settings.
3. Choose: Screen Search.
4. Swipe to activate it.

Computer Instructions:

1. Open a web browser (Explorer, Firefox, Google Chrome).
2. Type in this website:
   http://scouting.co1.qualtrics.com/jfe/form/SV_dmd7eLarNQM62rz