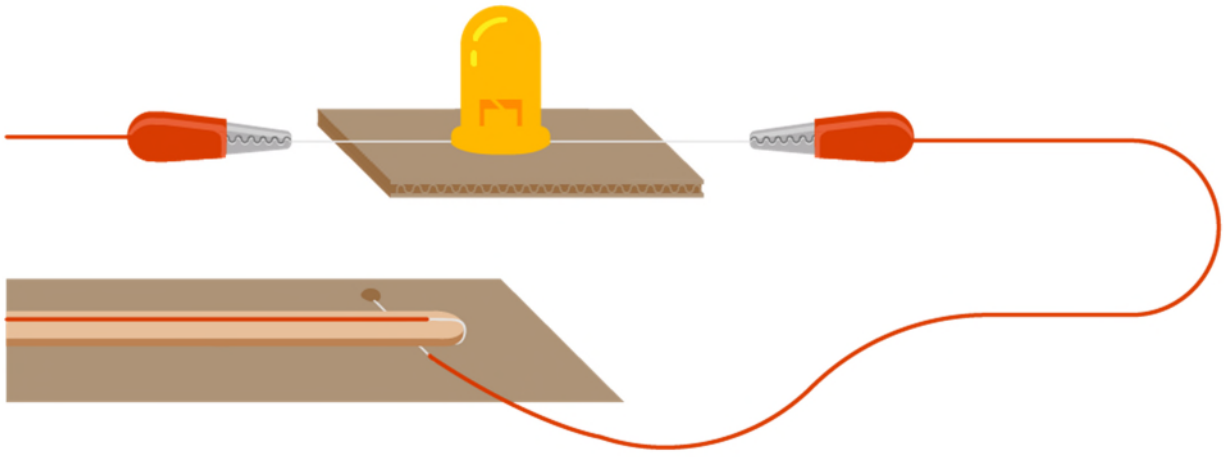
Student guide:
Making party lights using circuits and switches

Welcome young scientists and engineers!

Your mission:
From desk lamps to holiday lights, lights brighten our homes and affect our moods. The entertainment industry uses lights to create an atmosphere in Hollywood productions, Broadway musicals, and concert tours. Lights enliven a party and create a festive ambience.

Your class is getting ready to host a party for an annual celebration. Work closely with your teacher and classmates to create party lights to set the mood. Take on the role of a **lighting engineer** to create and control a sequence of lights. Lighting engineers use knowledge about electrical switches to manually and digitally control lights. In the following activities, you will learn the basics of an electrical circuit, building circuits, and how to control them.

Your teacher may invite you to present your party lights using Flipgrid. Good luck and have fun!



Prior knowledge

To get started, answer these two questions and then discuss your answers with your team:

1. What are two electrical devices you have in your classroom that are controlled by an electrical switch?

2. What do you know about battery-powered electrical circuits?

Draw your own light circuit

How does a battery-powered light with an on/off switch work? Explain with a labeled diagram.

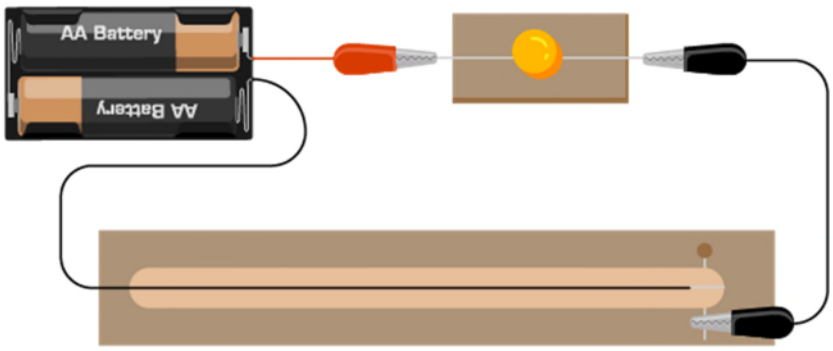
Vocabulary

After reading the definition for each electrical component used in a simple circuit, complete the table by giving two examples for each item.

Word	Definition	Student Examples
Power source	The power source provides electrical energy to the circuit.	1. 2.
Load	The load is any electrical device in a circuit that uses electrical energy to do work.	1. 2.
Conductor	A conductor is the material in a circuit that provides the path for electricity to flow between the components of the circuit.	1. 2.
Switch	A switch opens and closes a circuit, controlling when electrical energy flows through.	1. 2.

Build a switched electrical circuit

To better understand how the components of a basic circuit work, you will build a manually controlled electrical circuit and then connect it to an Excel workbook to control it digitally. Use these instructions to build your electrical circuit. This build process will mimic a lighting engineer's journey as they develop and test circuitry to create dynamic light displays.



Step 1: Assemble the power source

1. Why do chemical batteries have a positive and negative terminal?

2. What is the purpose of the power source in a circuit?

Step 2: Build the load

3. What is the role of the load in the circuit?

4. How can you tell what lead on an LED is positive and negative?

Step 3: Make the switch

5. What is the purpose of a switch?

6. Explain how the switch controls the flow of electricity through the circuit.

Step 4: Connect all components with a conductor

7. What is the purpose of using a conductor to join the other components to make a complete circuit?

Reflection

After testing the completed circuit, answer the following question:

8. What were some of the challenges you encountered while building the circuit?

Updated circuit diagram

Using your functioning circuit as a guide, redraw your diagram. Update your work based on your new understanding of how a battery-powered light with an on/off switch functions.

Refer to the Resource Guide on Basic Circuits to learn the fundamentals.

Create manual party lights

You can use your electrical circuit to create party lights. In your group, assign each team member a light number and follow this sample light sequence.

Sample Sequence								
Light	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**	**Step 8**
Light 1		x			x			x
Light 2			x	x			x	x
Light 3					x	x		
Light 4	x	x	x					x

Now design your own sequence! Use the table below to diagram your group's sequence.

Design Your Own Sequence								
Light	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**	**Step 8**
Light 1								
Light 2								
Light 3								
Light 4								

- Try to perform the sequence without mistakes.
- Consider what you liked about the lights and what you could improve on.
- Try another sequence or continue working to improve your original pattern. Perhaps you want to have the lights blink to the beat of a favorite song?

Please answer the following questions about your manual party lights experience:

1. What was the most effective part of your group's collaboration?

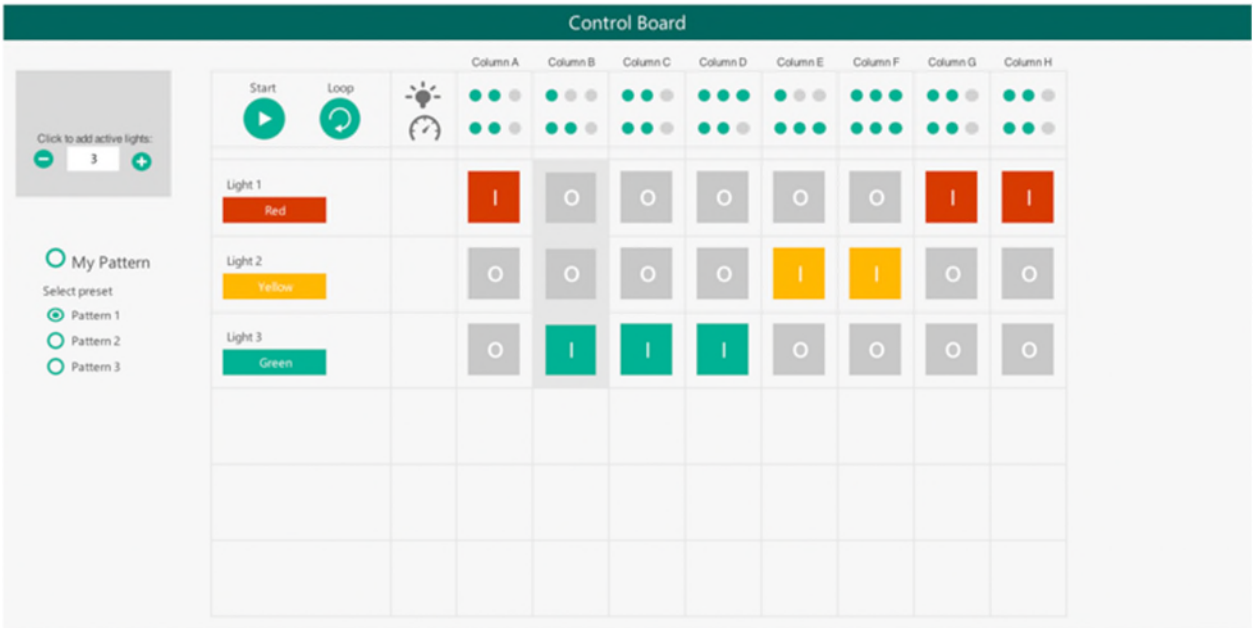
2. Suggest one change the group could make to improve its performance.

Visualization and control

Today's concerts and stage performances feature thousands of colors and complex styles of lights. To manage this intricate system, engineers must use computers. Using digital switches allows you to control not only when the light blinks on and off, but also the intensity and speed at which the light shines.

Using the build instructions, connect your electrical circuit to a microcontroller. Then connect the microcontroller to the party lights Excel workbook. In the workbook you will find preset sequences to explore.

From this workbook, your team will be able to program and control up to six individual lights. You will also be able to consider additional variables, such as brightness and speed.



After using the digital control board in Excel, answer the following questions:

1. What are the advantages of a digitally controlled light circuit compared to the manually switched circuit? Explain your answer.

2. Which additional controls would you want to add to the interface in Excel?

Record and share your party lights

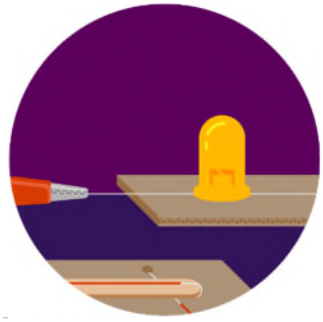
Share your party lights using Flipgrid. Your teacher will need to create a grid just for your class.

Resources

Use these resources to explore more information on stage lighting and electrical circuits.

Resource guide on Basic Circuits - Hacking STEM
What is a circuit? - SparkFun
How circuits work - How Stuff Works
Choreographing the dance of traffic lights - *The New York Times*
Stage lighting for students - Stage Lighting Primer
How to become a lighting technician - Careers in Music

Lesson plan:
Making party lights to understand electrical circuits and switches

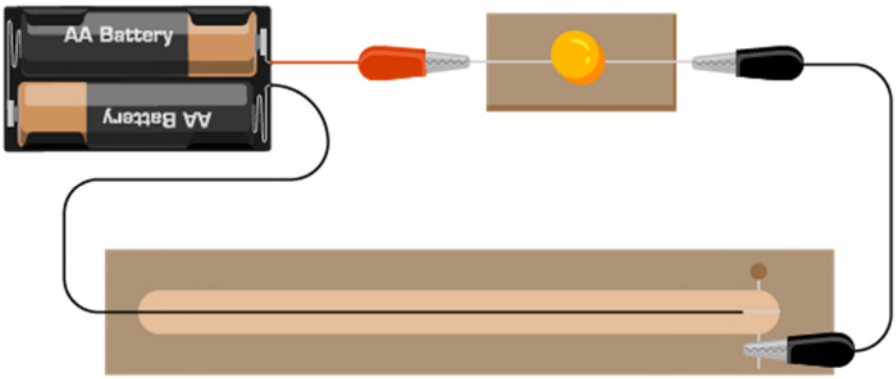


4-8th, 9-14 years | Three 50-minute class periods
Standards: NGSS, ISTE
This lesson plan is accompanied by a student guide.

This three-day activity introduces students to electrical circuits and how to use a circuit to create a light switch. Students construct electrical circuits consisting of four fundamental components—power source, load, conductor, and switch. With these circuits, students create party lights that are manually controlled or set to music they choose. Students then replace the DIY switch with a microcontroller connected to a custom Excel workbook. Here they learn the benefits of digital switching and light sequence coding. This interdisciplinary lesson places students in a real-world setting as they design a party lights for an upcoming school celebration. It leverages Excel's powerful visualizations to engage students in understanding the basics of circuitry and the benefits of digital switching. You may invite your students to present their light sequences using Flipgrid.

Watch this video to get familiar with the lesson.

Please note that lesson activities will require adult supervision.



Student activities

- Research the primary components of an electrical circuit.
- Draw a technical diagram of a basic circuit using industry standard symbols.
- Build a circuit and construct a switch that allows for manual control of an LED light.
- Connect a basic circuit to a microcontroller and Excel workbook to program light sequences.
- Present light sequences using Flipgrid.

Learning objectives

- Research the primary components of an electrical circuit.
- Draw a technical diagram of a basic circuit using industry standard symbols.
- Build a circuit and construct a switch that allows for manual control of an LED light.
- Connect a basic circuit to a microcontroller and Excel workbook to program light sequences.

Disciplines

- Physical Science
- Computer Science

21st century technical skills

- Electrical engineering
- Mechanical engineering

Standards

NGSS Practices 4-PS3-Energy

Performance Expectations

4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.

4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Science and Engineering Practices

4-PS3-3 Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

4-PS3-1 The faster a given object is moving, the more energy it possesses.

4-PS3-2, 4-PS3-3 Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

Crosscutting Concepts

4-PS3-4 Engineers improve existing technologies or develop new ones.

ISTE

5d: Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

Lesson materials

- Student guide
- Excel workbook
- Build instructions
- Resource guide: Basic Circuits
- Flipgrid: Party Lights

Teacher preparation

Consider these tips to implement the lesson in your classroom:

- Complete each component of the lesson yourself before teaching it.
- Refer to the resources below for background information and to customize the lesson for your classroom.

Suggested teaching timeline

Day 1: Lesson introduction, prior knowledge, vocabulary, draw your own light circuit.

Day 2: Build light circuit and answer questions in student guide.

Day 3: Connect light circuits to microcontroller, program lights to a blinking pattern in the Excel workbook.

Time-saving options

- Create a grounding plate in advance of day two activities
- Pre-flash microcontrollers with party lights code
- Precut cardboard for switch build
- Prepare hot glue guns

Resources

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Related activities

Harnessing Electricity to Communicate
Bite-size lesson: Flashlight
Visit activity page

Technical Setup

This lesson uses Office 365 and Excel 2016 (desktop) on a Windows 10 computer.

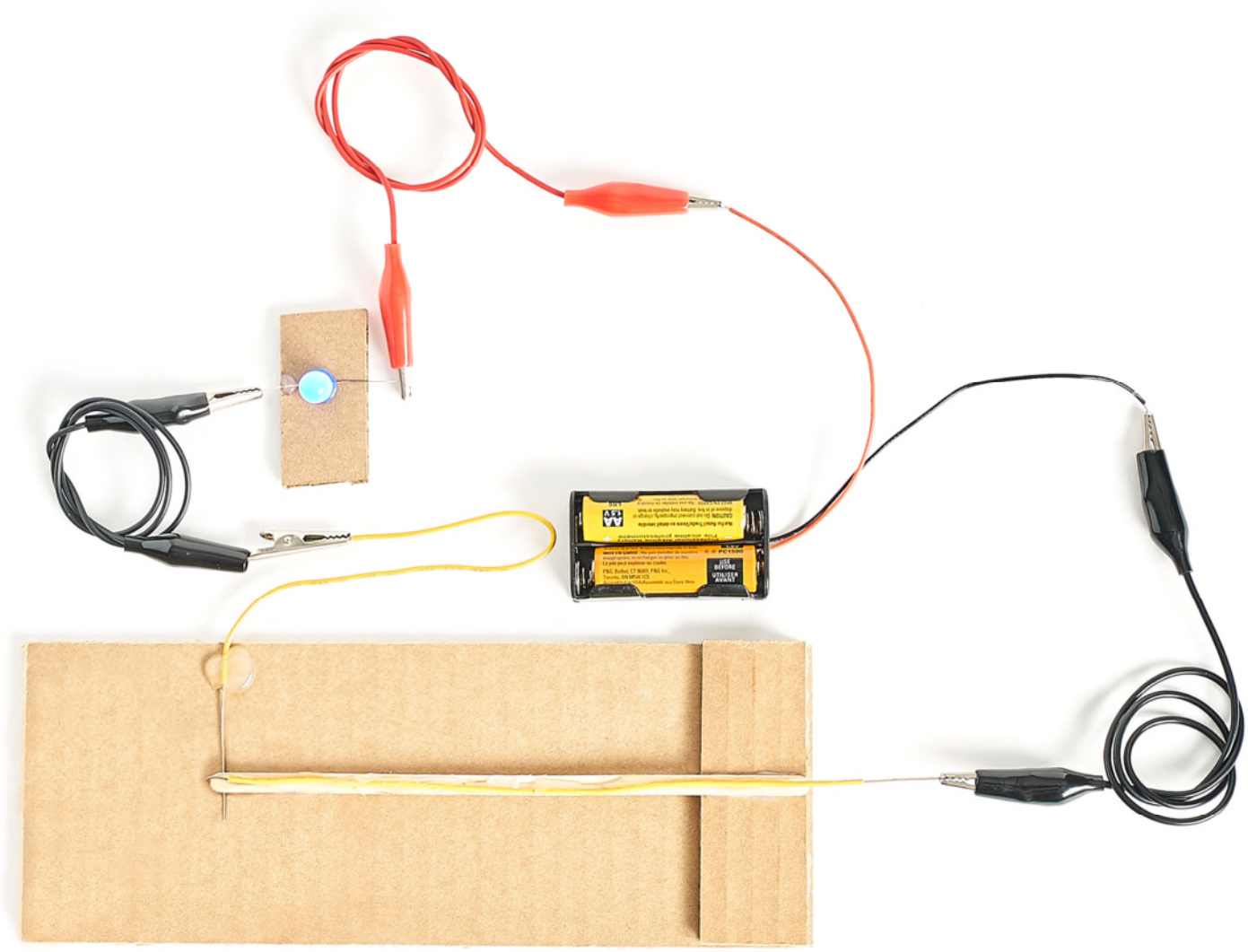
Assessment

The following rubric can be used as a guide for formative or summative assessment.

Learning Objective	4	3	2	1
Identify the four components of a basic electrical circuit.	Student can correctly identify the four components of a basic electric circuit and explain the function of each component.	Student can correctly identify the four components of a basic electric circuit and can explain the function of 2-3 components.	Student can correctly identify 2-3 components of a basic electric circuit and explain the function of 1-2 components.	Student is unable to identify the components of a basic electric circuit and cannot explain the function of the components.
Identify multiple examples for each component.	Student can correctly identify more than examples for each component of a basic electric circuit.	Student can correctly identify two examples for each component of a basic circuit.	Student can correctly identify one example for each component of a basic circuit.	Student is unable to correctly identify examples for each component of a basic circuit.
Construct a manually switched light circuit.	Student can construct a manually switched light circuit with all four components and can explain the function of each component.	Student can construct a manually switched circuit with all four components.	Student can construct most of a manually switched circuit but may be missing a component.	Student is unable to construct a manually switched circuit.
Program light sequences using a microcontroller-controlled switch and a custom Excel workbook.	Student can program a light sequence using a microcontroller-controlled switch and can explain the benefits to digital switches.	Student can program a light sequence using a microcontroller-controlled switch.	Student can partially program a light sequence using a microcontroller-controlled switch but may be missing a component.	Student is unable to program a light sequence using a microcontroller-controlled switch.
Demonstrate understanding with annotated sketches and answers in a student journal	Journal was complete with comprehensive answers and annotated sketches.	Journal was mostly complete with comprehensive answers and annotated sketches.	Journal was incomplete with inconsistent answers and annotated sketches.	Journal was not completed or represented significant lack of understanding of the lesson activities.

Microsoft

Hacking STEM

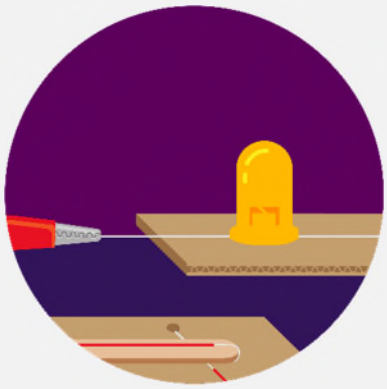


CIRCUITS AND SWITCHES

Making party lights using circuits and switches

Lesson plan and more resources are available at: aka.ms/hackingstem

Activity overview



In this project, students learn the basics of electrical circuits and switches by building a string of party lights. Then using Excel, they can create their own light sequences to record and present.

View the full lesson plan mapped to NGSS and ISTE standards, materials and activities to support this unit at aka.ms/party-lights-lesson/en

Please note that lesson activities will require adult supervision.

Build and learn

Students build party lights to visualize circuits in a physical realm. They can then begin to understand the flow of electricity and polarities.

Connect your tools

Digitize your device using either the Arduino Uno or micro:bit. Students learn essential prototyping and electrical engineering skills by connecting the lights to Excel to create light sequences.

Visualize the data

Students connect their device to an Excel workbook which displays real-time feedback from student-built circuits and switches.

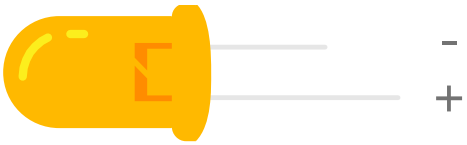
Contents

Hack our projects

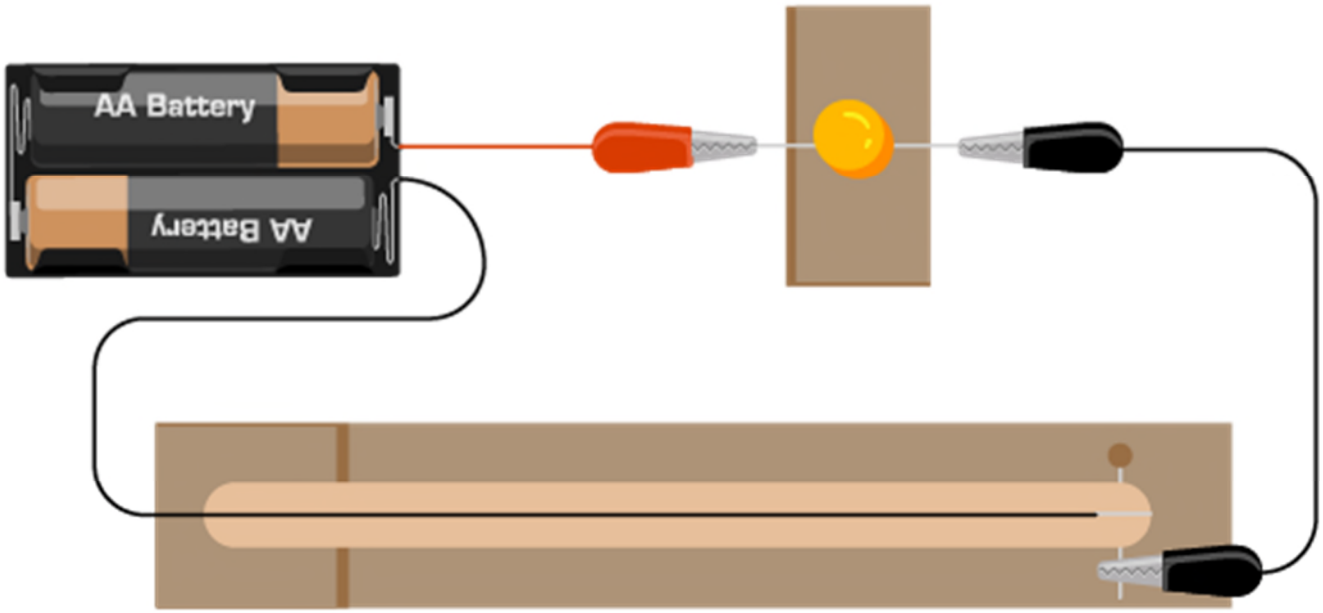
We love innovation and encourage you to hack our projects and make them your own. Submit your ideas at aka.ms/hackingstem

Part 1: Analog circuit

LED stands for light emitting diode. The longer leg of an LED is the positive leg and the shorter LED leg is the negative.



Below is a representation of a circuit. The power source is two AA batteries and the load is the LED.
A switch controls the flow of electricity through the wires.



What do the red and black wires do? Different colors of wire communicate the parts of a circuit.

Red typically means the positive side of the circuit.
Black typically means the negative side of the circuit.

Refer to the Resource guide on basic circuits for additional information.

Things you'll need

Materials

1 LED
3 alligator clips
1 2xAA battery holder
2 AA batteries
1 wooden craft stick
2 pieces of solid core wire (30 cm)
5 pieces of cardboard (2.5 cm x 10 cm)
1 piece of cardboard (10 cm x 25 cm)

Toolkit

hot glue gun*
wire strippers
scissors
permanent marker
pencil

** If a hot glue gun is not available, use tape instead. Clear tape or masking tape work well*

Safety guidelines

Hot Melt Tool

- *Place it on a level surface to avoid tipping over.*
- *Place the electrical cable out of the way to avoid a tripping hazard.*
- *Do not touch the tip of the tool or the hot glue coming out of it.*

Eye Protection

- *Please wear appropriate eye protection while doing any engineering design or field projects.*

Cutting Tools

- *Keep the sharp edge away from your body.*
- *Always cover the blade with a plastic cap when not in use.*
- *When cutting small pieces, do not place fingers very closed to the blades.*

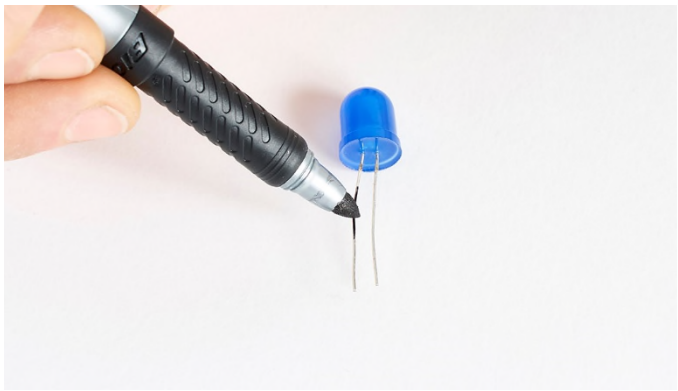
Wire Strippers

- *Always keep your fingers and hands out of the cutting area.*

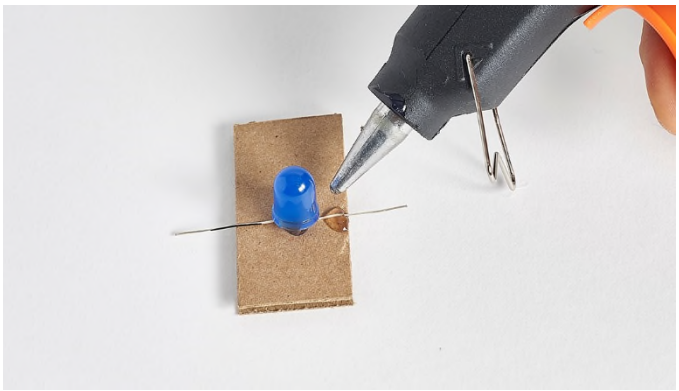
Making for a group or need help finding materials?
View the shopping list to calculate quantities at: aka.ms/party-lights-materials/en

Build a base for the LED

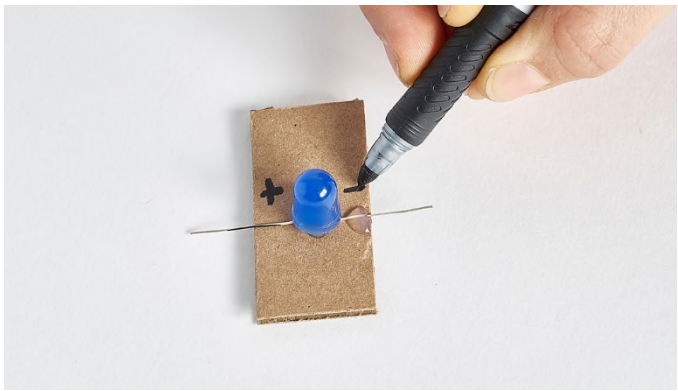
1 | Gather the LED, 2.5 cm x 10 cm piece of cardboard, and your marker. Turn on your hot glue gun.



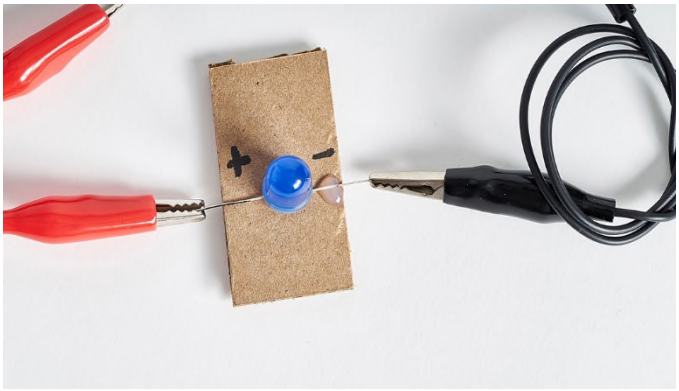
2 | Mark the longer LED leg with a marker.



3 | Bend the LED legs flat. Glue the top of the LED to the cardboard. Extend the LED legs past the cardboard to more easily connect alligator clips.



4 | Mark a positive (+) symbol next to the longer leg of the LED and then mark a negative (–) symbol next to the shorter leg to represent the positive and negative ends of the LED.



5 | Attach your alligator clips to the LED legs. It is helpful to use a red alligator clip for the positive end and a different colored alligator clip for the negative end. Alternatively, use two different colored alligator clips for the positive and negative ends.

Build a switch

1 | Gather the 10 cm x 25 cm piece of cardboard, 2.5 cm x 10 cm piece of cardboard, wooden craft stick, 2 pieces of wire and wire strippers. Make sure your glue gun is ready.

2 | Glue 2.5 cm x 10 cm cardboard piece to one end of the 10 cm x 25 cm cardboard.

3 | Put hot glue onto the end of the craft stick.

4 | Attach the stir stick by gluing one end of the stick to the top of the cardboard stack.

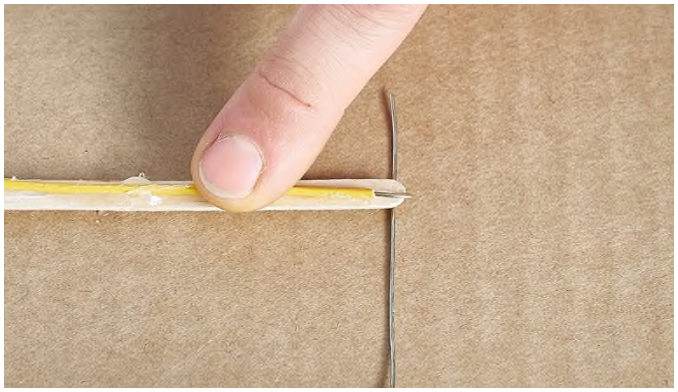
5 | Using the wire strippers, remove 5 cm of insulation from one side of the wire. **This is the longer bit of exposed metal.** On the other side of the wire, remove about 1 cm of insulation. Repeat for the second wire.

6 | Take one wire and bend the longer bit of exposed metal (5cm). This will be the top wire for our switch.

7 | Slide the bent wire onto the craft stick with the exposed end facing the cardboard. The longer bit of exposed metal (5 cm) goes under the craft stick.

8 | Make sure the bent wire is snug up against the end of the craft stick.

8 | Glue the wire to the craft stick. Avoid getting glue on the exposed metal as this would prevent electricity from flowing through our circuit.

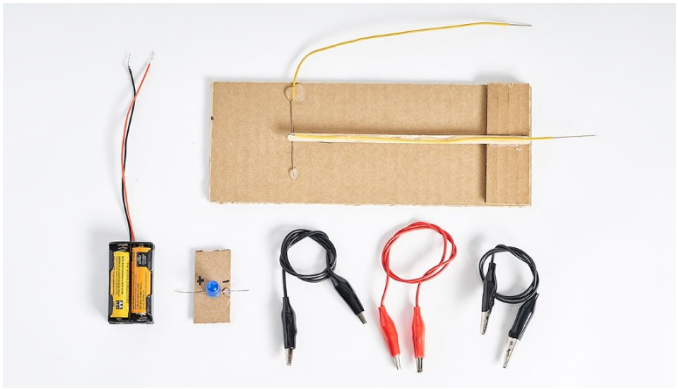


9 | Add the second wire under the craft stick. Move the wire so that the exposed metal sits under the metal of the first wire. Before you glue the second wire down, test that the metal of both wires touch when you press down on the craft stick.

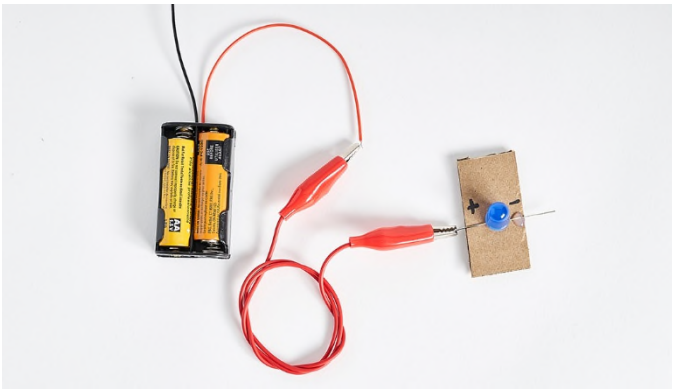
10 | If the metal parts touch, glue down the second wire. Again, avoid coating all the exposed metal in glue.

Congratulations! You've completed your switch!

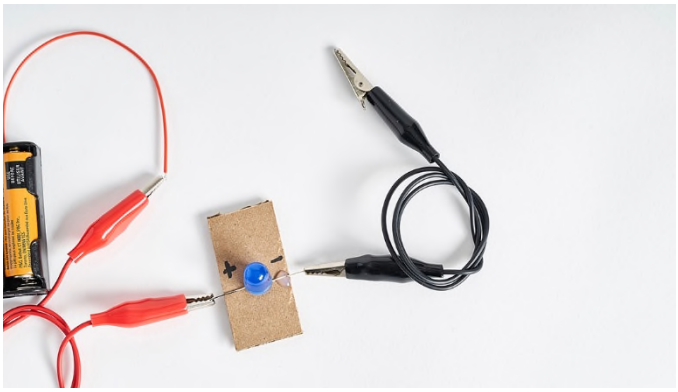
Finish the circuit



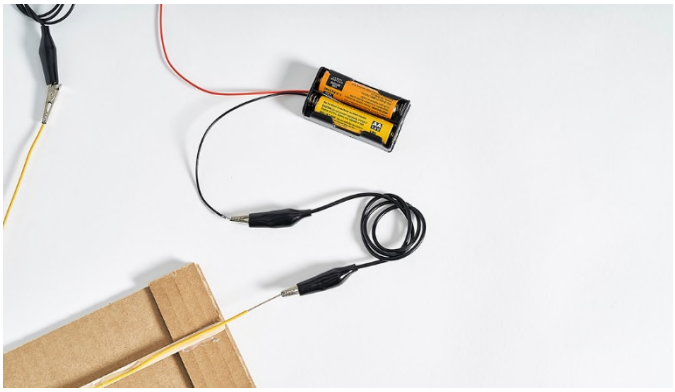
1 | To complete your circuit you will need your completed switch and LED as well as 3 alligator clips and a battery case with 2 AA batteries.



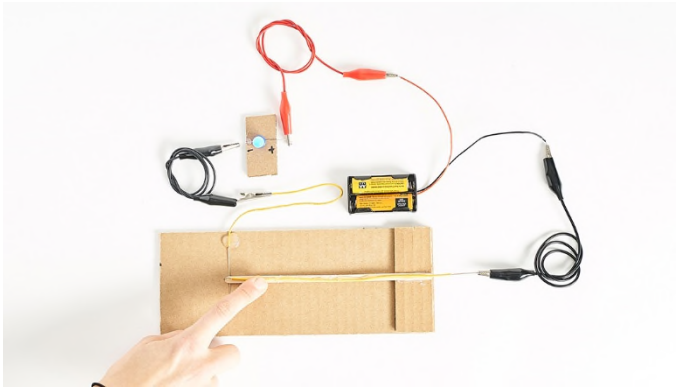
2 | Connect an alligator clip between the positive (red) battery case wire to the positive LED leg (the one marked with a marker).



3 | Connect an alligator clip between the other LED leg and the bottom wire of the switch.



4 | Connect an alligator clip between the negative (black) battery case wire and the top wire of our switch.



5 | Test your circuit! Press down on the switch and check that the LED turns on.

Circuit not behaving as expected?

Compare your circuit with your neighbors, then check the following:

1. Check the polarity, or orientation, of the LED. Flip the LED around and test if it turns on.
2. Check that the batteries are correctly oriented in the battery case.

Lastly, check that the electricity has a clear path to flow through the metal in our wires. The metal teeth of the alligator clip should be touching the exposed metal of the wires.

Part 2: Digital circuits

Things you'll need

Materials
2 lights glued to cardboard
2 alligator clips
3 pin-ended alligator clips
1 small piece of cardboard (approx. 4 cm x 10 cm)
4 strips of copper tape (approx. 9 cm)

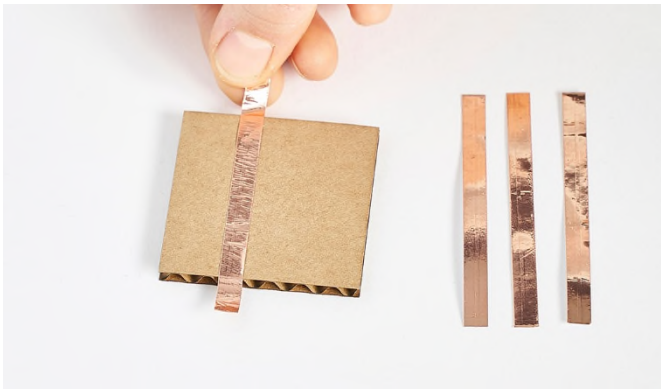
Reusables
1 microcontroller (Arduino or micro:bit)
1 edge connector (if you are using micro:bit)
1 USB cable A-to-B for Arduino
1 USB cable micro for micro:bit
1 breadboard

Making for a group or need help finding materials?
View the shopping list to calculate quantities at: aka.ms/party-lights-materials/en

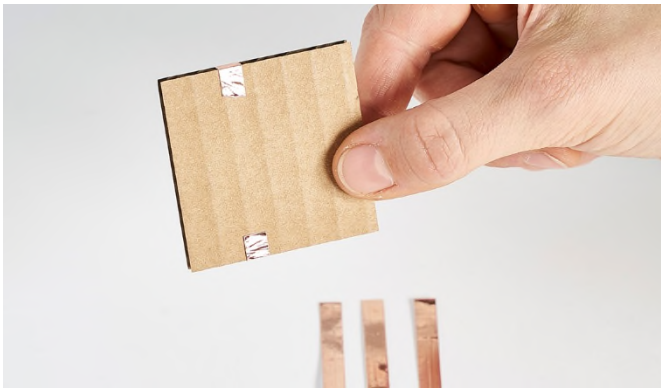
Make a ground pad

A ground pad is a useful addition to our circuit because it makes connecting multiple lights easier.

1 | Grab the materials for the ground pad. Cut four strips of copper tape about 9cm long.



2 | Remove the adhesive from the copper tape and wrap around the cardboard.

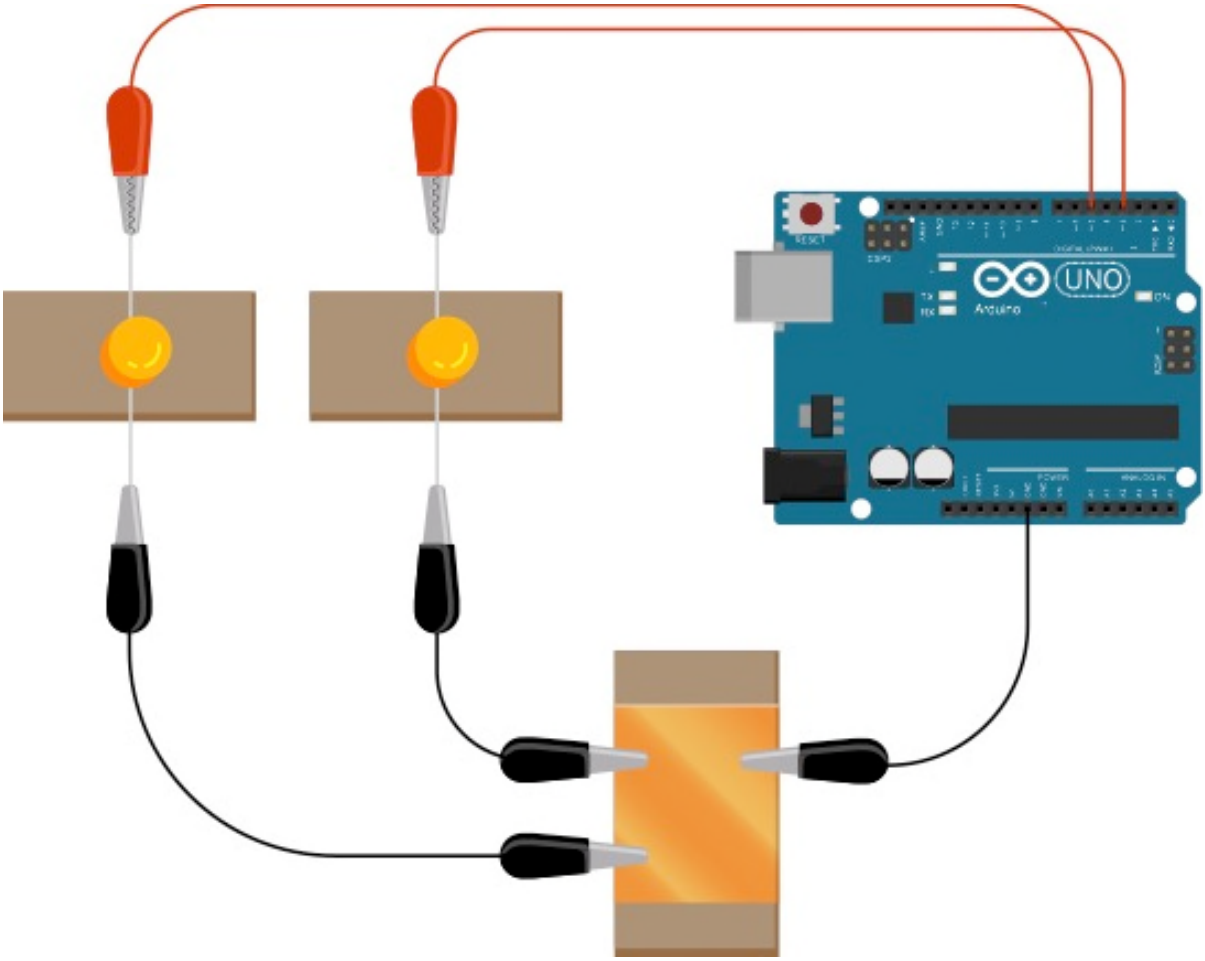


3 | For the best connection, wrap the tape around the cardboard so the teeth of an alligator clip make contact on both sides

4 | Use the ground pad to connect all negative, or ground, alligator clips.

Connect LEDs to the Arduino

Instead of manually turning our lights on and off, we can use a digital switch! For this, we'll use an Arduino microcontroller to program the LEDs.



1 | Connect the ground pad. Grab a breadboard to alligator clip and plug the breadboard pin into an Arduino GND pin. Connect the alligator clip to the Ground Pad.

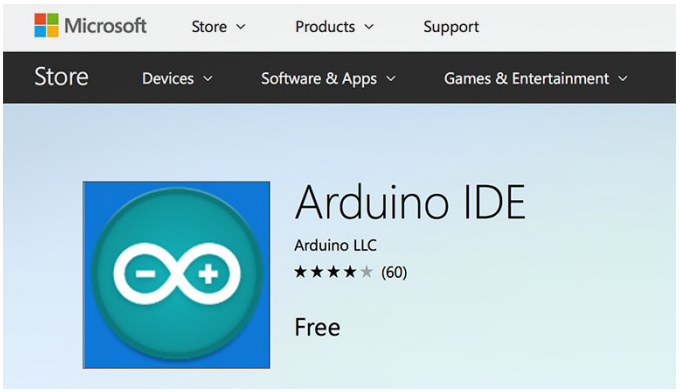
2 | Connect an alligator clip between the negative LED lead and the ground pad. If you are not using the ground pad, connect the LED alligator clip lead directly to the Arduino GND alligator clip lead.

3 | Using a breadboard-to-alligator clip, connect the positive lead of the first LED to **Arduino Digital Pin 3.**

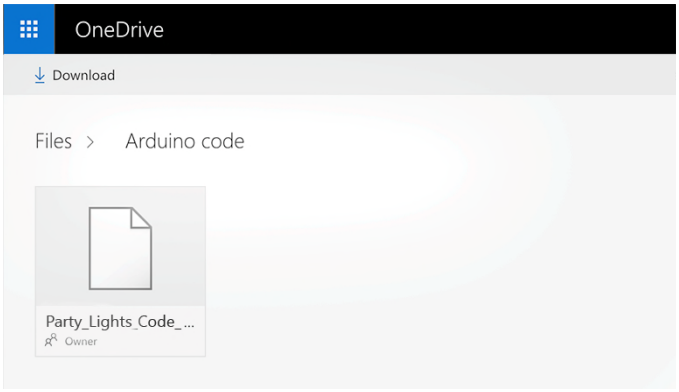
4 | For each successive LED, repeat Steps 2 – 3 but use Arduino Digital Pins 5, 6, and 9.

For each pin to function properly, we need to use the Arduino Pulse Width Modulation, or PWM, pins. These pins have a ~ next to them. We can add up to 6 lights, with the 5th and 6th lights using Arduino Pins 10 and 11.

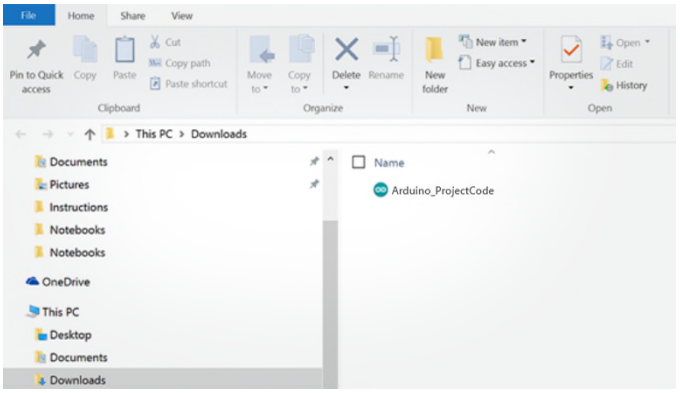
Upload Arduino code



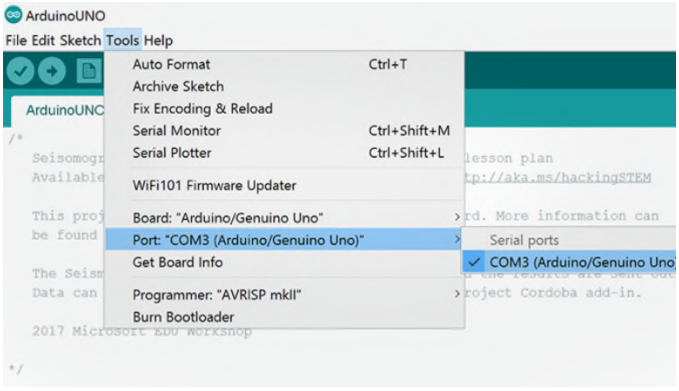
1 | Install the Arduino IDE from the Technical Requirement link on the lesson page at aka.ms/hackingSTEM or through the Microsoft Store. Follow prompts to complete the installation.



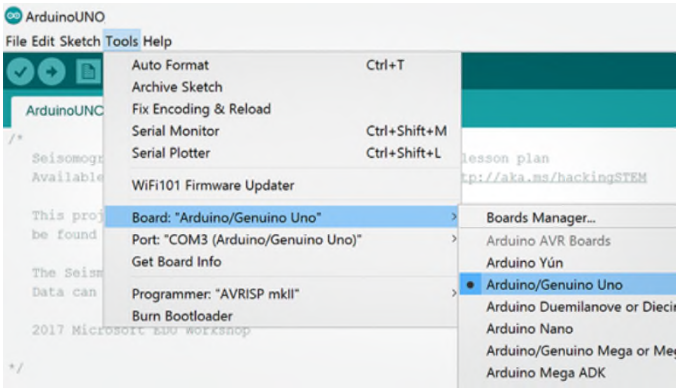
2 | Go to aka.ms/party-lights-code and download the flash code.



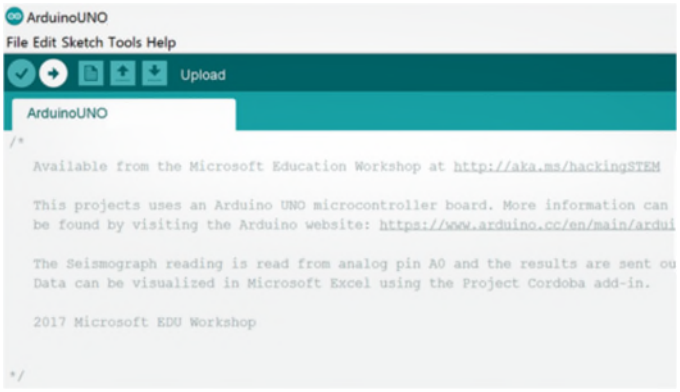
3 | Open your downloaded file to launch the Arduino app.



4 | In the Arduino app, select: Tools > Port > COM 3 (Arduino/Genuino Uno). Your port may be different than COM3.

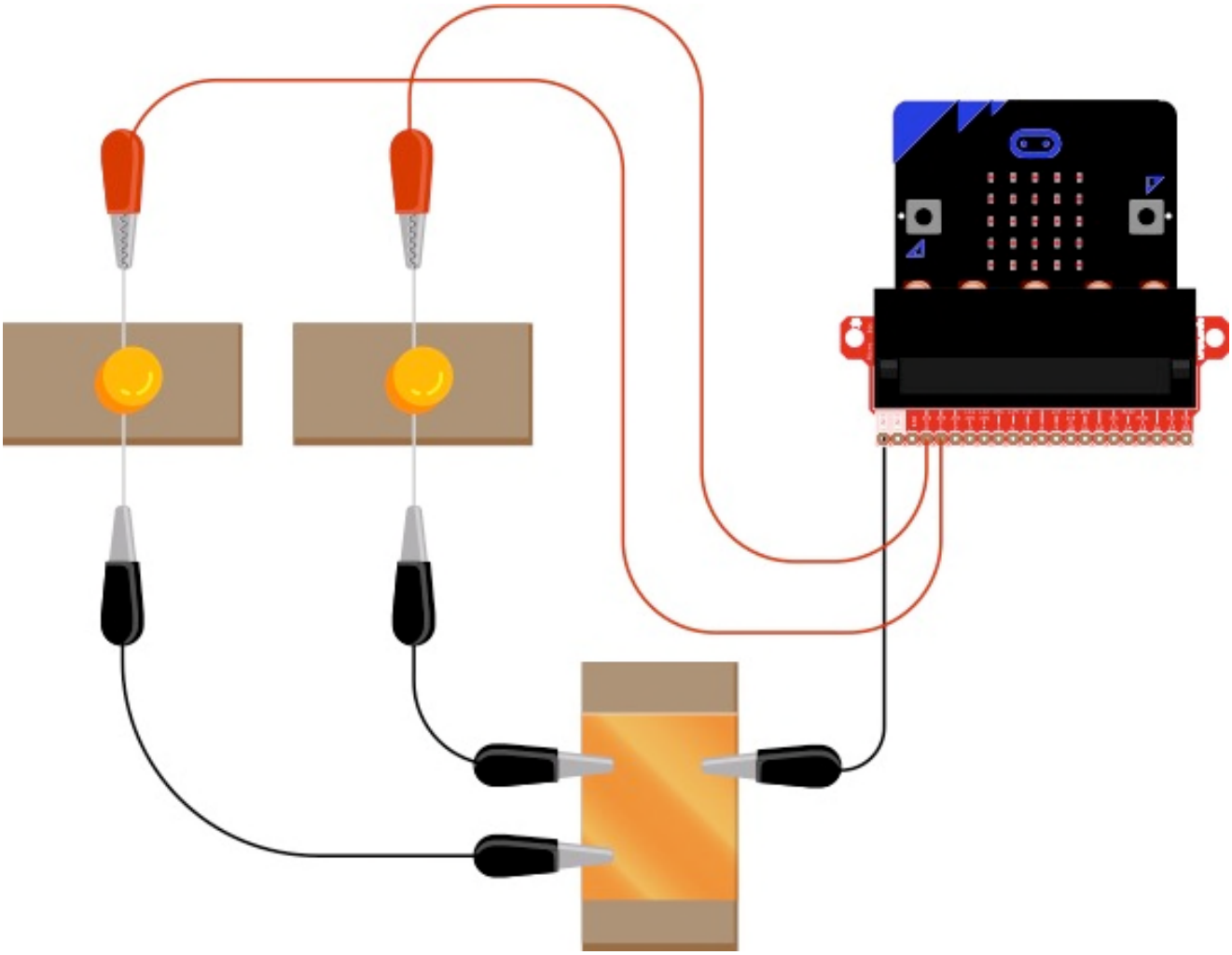


5 | Then select Tools > Board: Arduino/Genuino Uno.



6 | Click on the circular right arrow button to upload.

Connect your micro:bit



1 | Connect the ground pad! Insert the male-to-female jumper wire into one of the Micro:Bit pins labeled “GND.”

2 | Connect an alligator clip between the jumper wire and the ground pad.

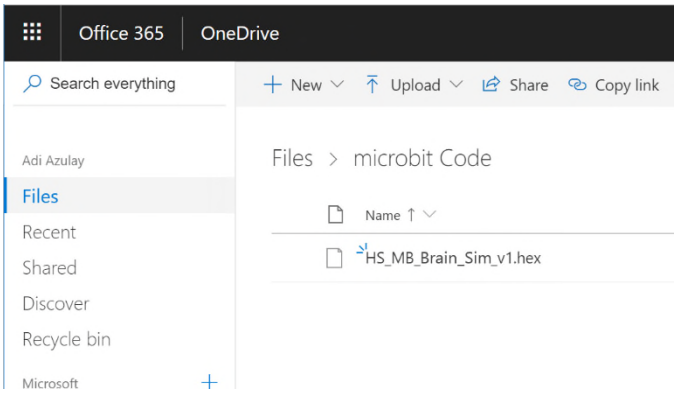
3 | Grab an LED and insert the **longer** leg into the Female-to-Female jumper wire.

4 | Using an alligator clip, connect the shorter LED leg to the ground pad
If you are not using the ground pad, connect the LED alligator clip lead directly to the micro:bit GND alligator clip lead.

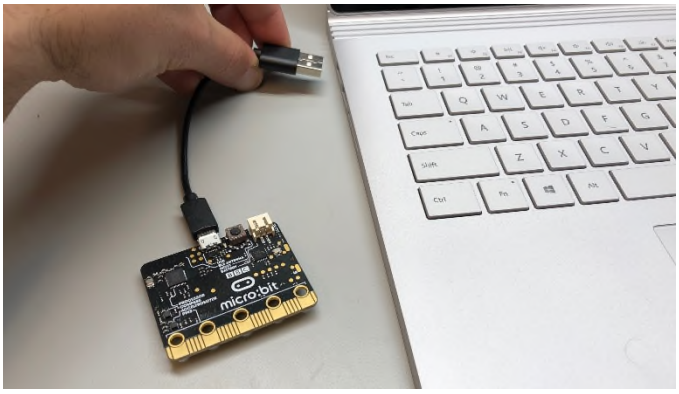
5 | Connect the female-to-female jumper wire to the micro:bit Analog Input pin0.
Tip: Look closely at the Edge Connector for the pin labels.

6 | **For each successive LED, repeat Steps 4 – 5 using micro:bit pins 1 - 4** See circuit schematics below and on the following page.

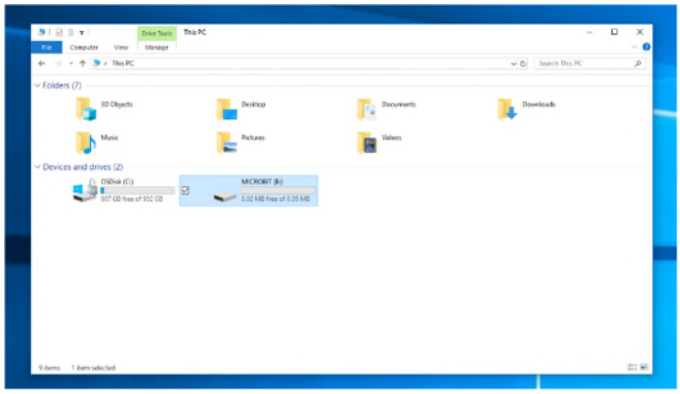
Upload micro:bit code



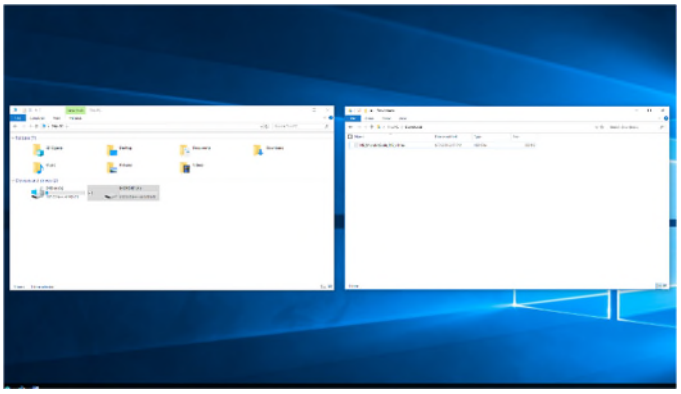
1 | Go to aka.ms/party-lights-code to download the .hex code file.



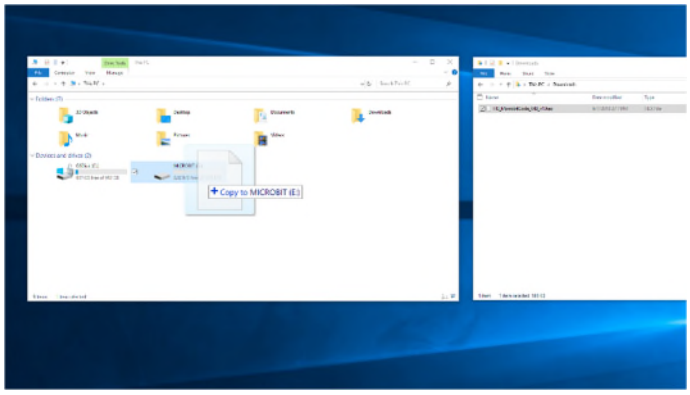
2 | Plug your micro:bit to your computer using a USB cable. Install the mbed driver. If you've done this before, you won't have to do it again.



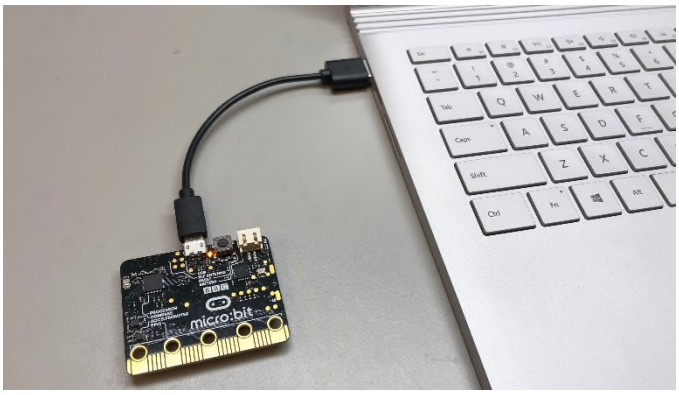
3 | In File Explorer, navigate to the micro:bit. It will appear like an external storage device (e.g. thumb drive, hard drive, etc.).



4 | Open a second File Explorer window and navigate to the downloads folder. Make sure you can see both windows.



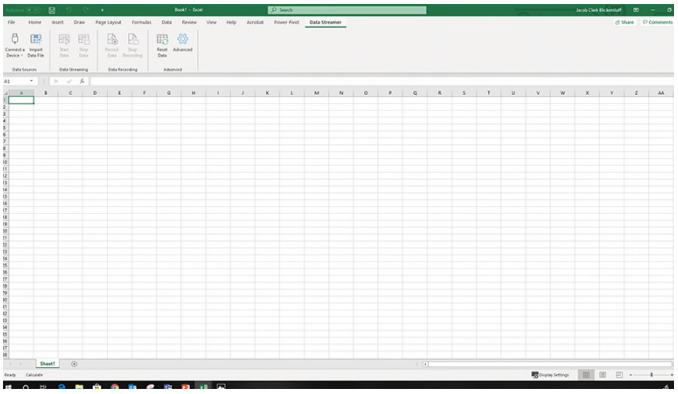
5 | Select the .hex file in downloads and drag it to the micro:bit window.



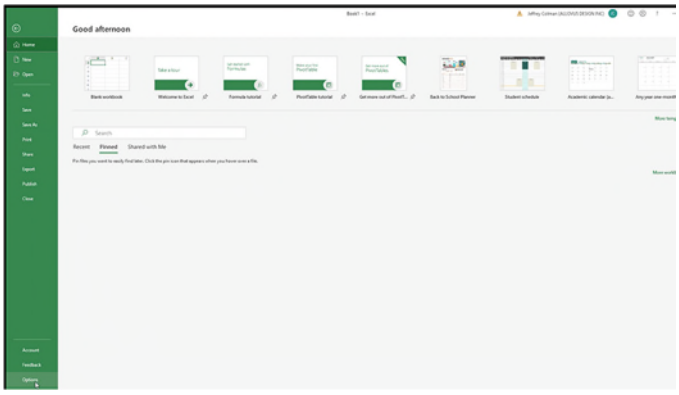
6 | Once the LED light stops blinking, the code has been uploaded onto the micro:bit.

Open Excel and enable Data Streamer

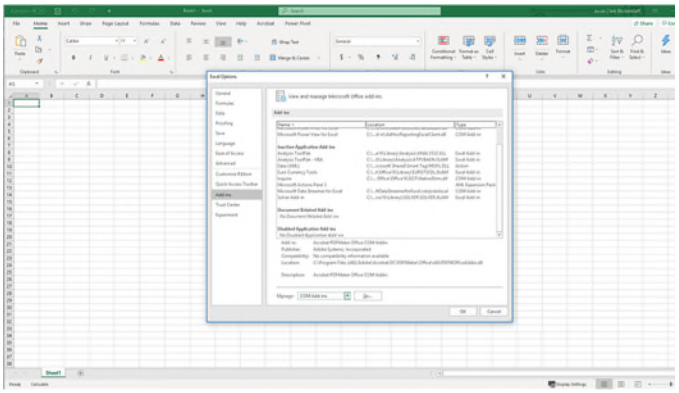
Data Streamer with Excel O365. The O365 subscription includes Excel and the Data Streamer add-in for free.



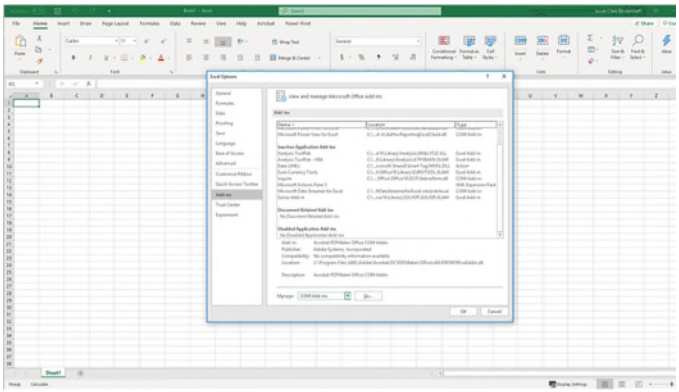
1 | Open Excel 0365**.**



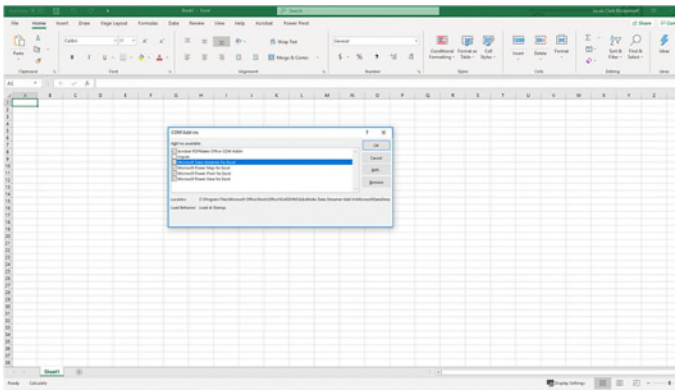
2 | Click on **File** and choose **Options** located at the bottom of the pane.



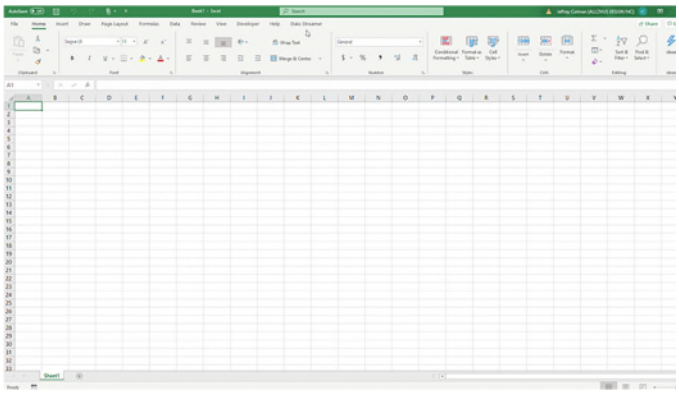
3 | Choose **Add-ins** in the dialog that opens.



4 | From the **Manage** menu at the bottom of the dialog that opens, choose **COM Add-Ins** and click **Go**



5 | Check the box for **Microsoft Data Streamer** in the dialog that opens and click **OK.**



6 | You should see a new Data Streamer tab in Excel's menu ribbon.

Data Streamer with Excel O365 desktop version

For a limited time, Data Streamer can be used with the desktop version of Excel 2016. Download Data Streamer from the Microsoft Store. After installation, Data Streamer will be automatically enabled in Excel.

Get ready to visualize data

To run the Data Streamer Add-in, make sure you meet these technical requirements:

- PC running Windows 10 and Excel O365 Desktop.
- Enable the Data Streamer add-in. See instructions on previous page.
- Customized Excel Workbook available at: aka.ms/party-lights-workbook

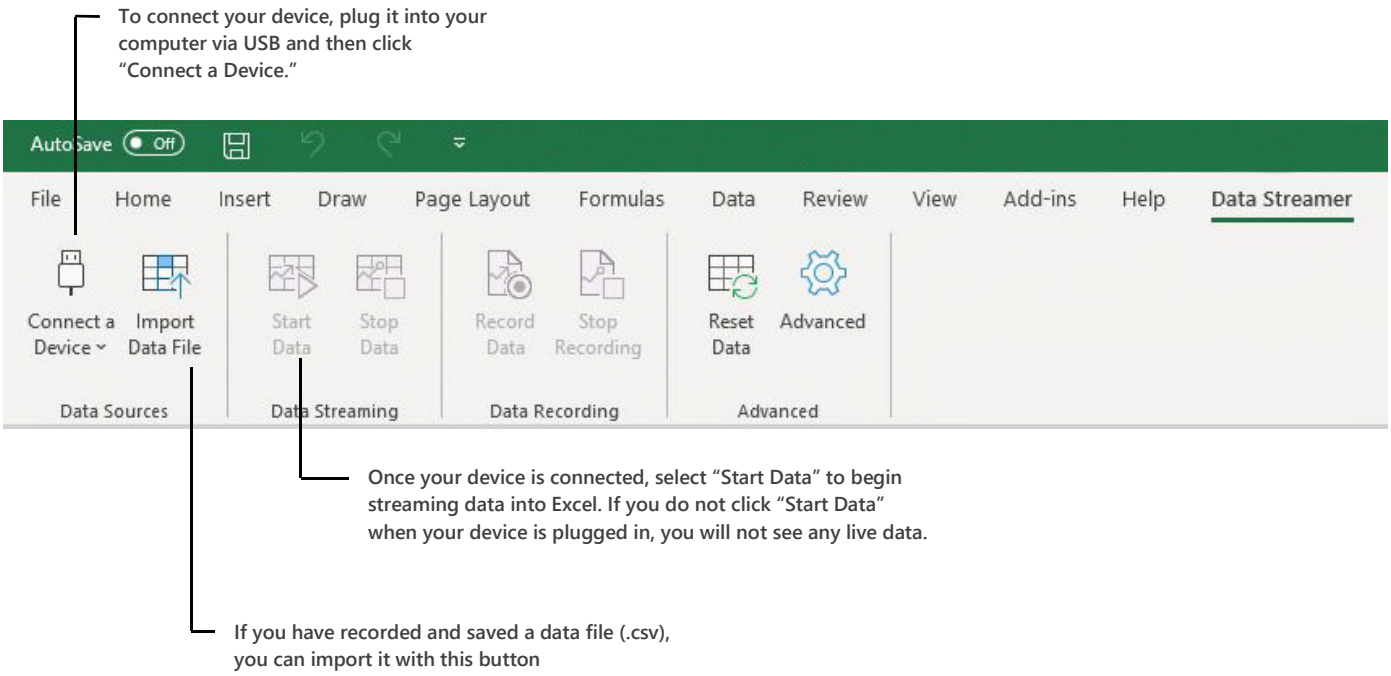
Congratulations! You are now ready to visualize real-time data from the Electroconductivity sensor sensor. To see live data, follow these steps:

1 | Plug the Arduino or micro:bit microcontroller into your computer's USB port

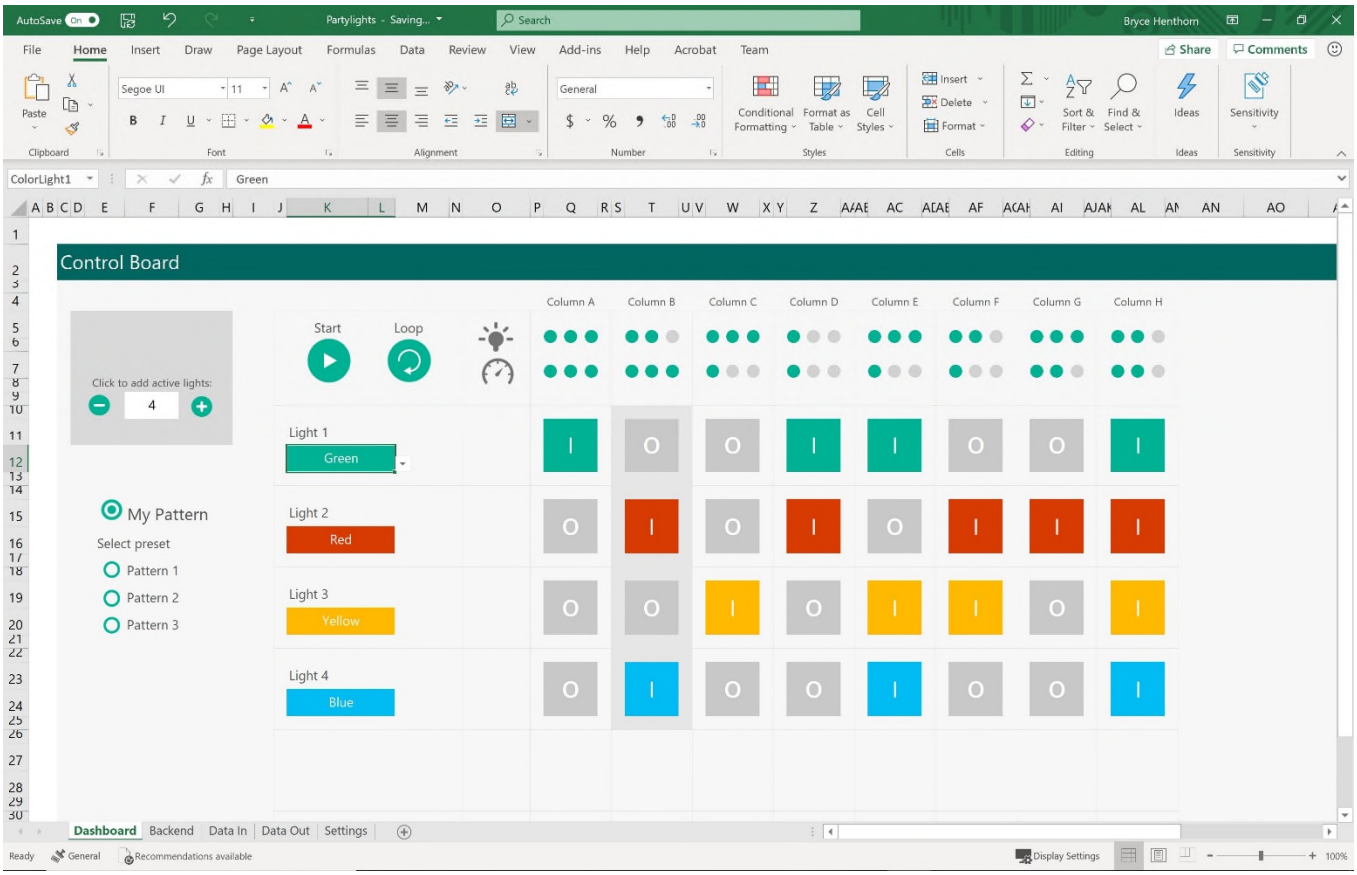
2 | Click the Data Streamer tab on the Excel ribbon

3 | Click Connect a Device to connect Excel to the microcontroller

4 | Start Data to begin streaming data into Excel



Excel workbook basics



Dashboard

In this sheet you can create your own set of light patterns. Start by setting the number of lights you have connected to your board. Once the Control Board shows the corresponding correct number of lights, you can start creating your own pattern.

Presets

To explore ideas for your own pattern, you can select one of three presets. These show a pattern of lights, with varying brightness, color, and speed.

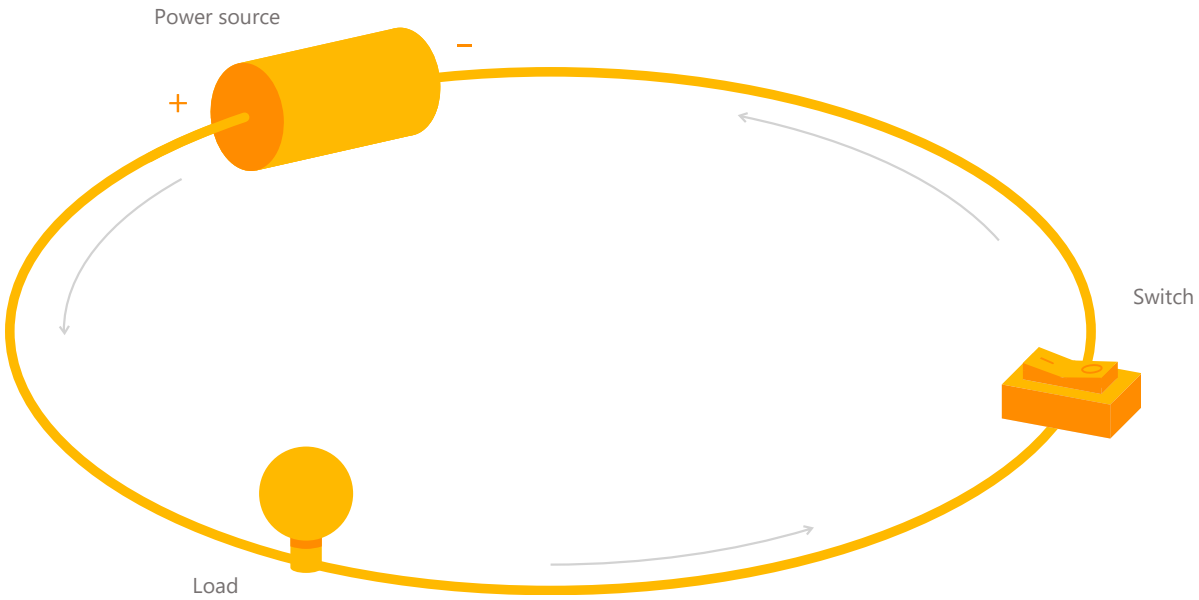
Hacking STEM Resource Guide

Basic Circuits

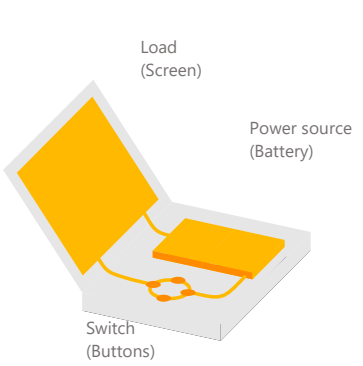
Many Hacking STEM projects, like Morse code, Hot wheels, and Joystick, use a switched circuit and a DC power supply to function. This resource introduces the components and functions of a basic circuit.

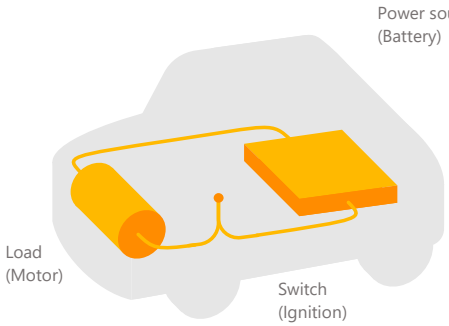
The basic circuit

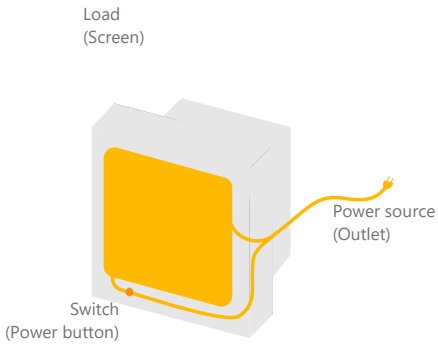
A circuit is a path for an electric charge to travel from one location to another. When the electric charges are moving in the path, they can be used to perform work, like turning on a light.



Electrical circuits are found in every device that uses electricity. Some examples of items that use electrical circuits are video game consoles, electric cars, and televisions.

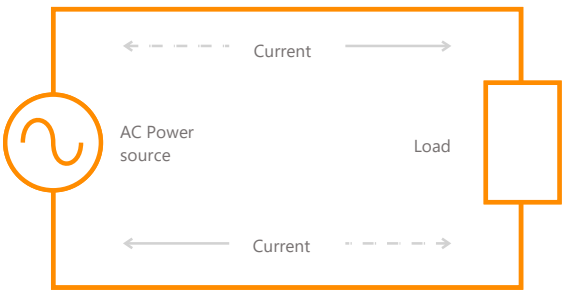


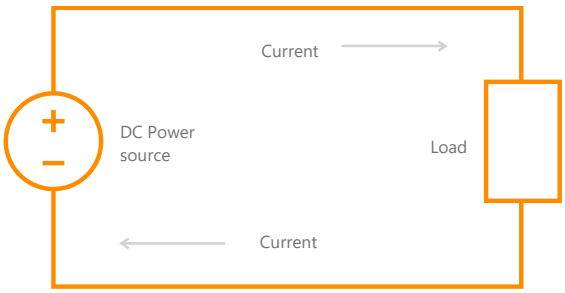




Alternating and direct current

There are two types of electricity—direct current (DC) and alternating current (AC). The circuits used in Hacking STEM activities operate on direct current (DC). Batteries, Arduino microcontrollers, and computers use this type of electricity.

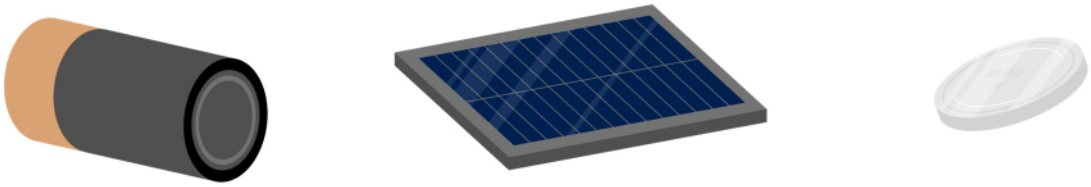




Direct current electricity flows in a circle from positive (+) to negative (-). The power source, like a battery, drives the flow of electricity, which is also called electric current, or current for short. Various components connected between the battery terminals use the electric charges generated in the battery to perform work such as lighting a room, turning a motor, or heating a house.

Components of a basic switched circuit:

Power source

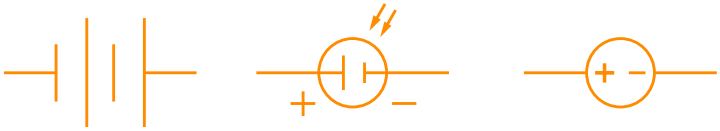


The power source provides the electrical energy for the circuit. A battery is a common DC power source for a circuit. A battery is comprised of three basic elements—the cathode (+) material, the anode (-) material and the electrolyte.

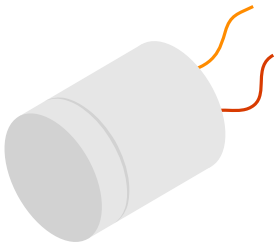
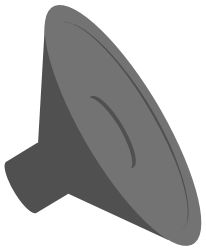
When a component is connected between the battery terminals, the anode material provides negative charges, or electrons. As the anode material loses more and more negative charges, it attracts positive ions from the cathode. The electrolyte allows the positive ions to travel from the cathode to the anode, which maintains the flow of electricity.

The battery is dead when the anode and cathode materials are "used up," so that no more electric charges can be generated.

DC Power symbols:



Load

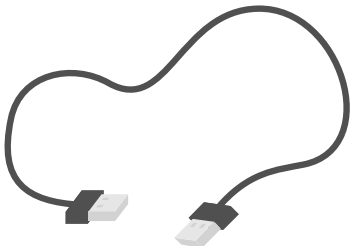
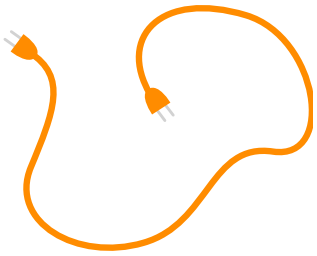




The load in a circuit is the device performing work. It can be an active or passive device. Examples of active loads are solenoids, motors, and speakers. Examples of passive loads are lights and heaters. Some loads, such as an LED, are polarized—these components only allow electricity to flow through them in one direction. Polarized loads have symbols to inform you which terminal connects to the positive side of the circuit. On an LED, the longer wire terminal is the positive lead (+). The symbol for a load depends on the device.

Load Symbols:

LED Motor Speaker

Conductor

The conductor is the material in a circuit that provides the path for electricity to flow. Good conducting materials include most metals like copper, silver, and gold. Not all materials are good conductors: Insulators are materials that do not easily allow electricity to flow through them. In Hacking STEM activities, we use conductive metal wire surrounded by an insulating material such as plastic or enamel. The insulative coating on the wire helps to direct the flow of electricity and prevent it from going somewhere we don't want it to. It also allows us to hold the wire while the electricity is flowing so that we don't get shocked*.

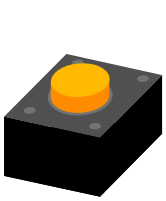
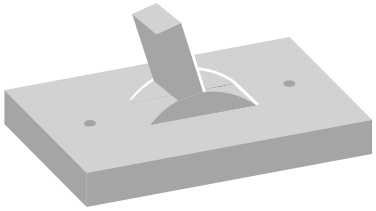
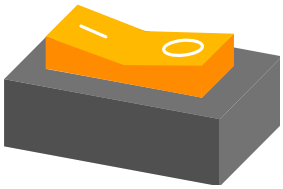
At the beginning and end of the wire, we remove, or strip, the insulation coating to connect it to each of the electrical components in the circuit. Any break in the conductor will stop the flow of electricity. The term "continuity" means an uninterrupted path of conductive material.

Conductor symbol:

Electrical wire

*Although we recommend working with insulated wire for safety purposes, Hacking STEM activities do not use dangerous electrical energy. Use extreme caution if you ever use a voltage source higher than 25VDC.

Switch

A switch opens and closes a circuit, controlling the flow of electricity. An essential use for a switch is to turn off an electrical device. Switches can be operated both manually and electronically. An example of a manual switch would be the light switch in your classroom. An electronic switch is a switch that uses an electrical current to turn on and off an electrical circuit. Electronic switches are used where manual control by humans is too dangerous, like inside a nuclear reactor, or in a place where humans cannot visit, like Mars. Electronic switches are also used when the number of switches needed are too numerous or the speed required to operate is too fast for humans to control.

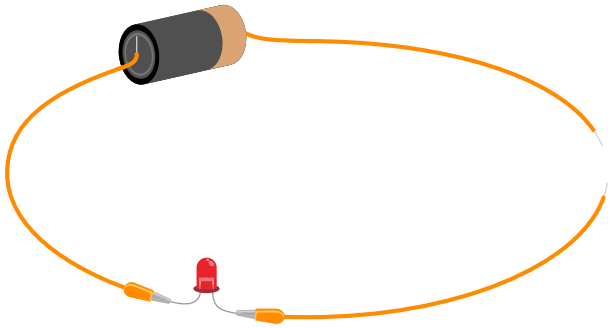
Switch symbols:

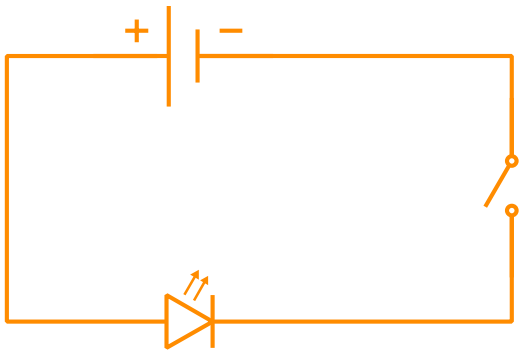

Toggle switch


Push button switch

How to draw a circuit diagram

A circuit diagram is a graphical representation of an electrical circuit. A circuit diagram uses simple images of components, while a schematic diagram uses standardized symbolic representations.


Simple diagram



Schematic diagram

How does a circuit work?

A circuit only works when there is a complete, uninterrupted path of conductive material for the electrical current to flow between the terminals of a DC power supply. A device, or load, needs to be connected in the circuit path to perform work with the electricity, or else the electricity will perform work in the form of heat! A switch allows us to control when the electricity flows and when the circuit is off by breaking the path of conductive material.