

Focus: Conductivity & Circuits
Grade Level: 7
Session Length: 45-60 minutes

Driving Questions

- How can we use our understanding of circuits and conductivity to design an environmental sensor that can measure the amount of water in the soil?

NGSS Links

- Planning and Carrying Out Investigations
- Designing Solutions

Systems Thinking Characteristics

- Identifying Hidden Dimensions of the System

In the fifth session of Project Crystal Code, students build and test virtual circuits, then use their understanding of circuits and conductivity to create a plan to build a soil moisture sensor.

Students are introduced to their task for the next three sessions, which is to design and code a sensor that can measure soil moisture in our research site, which will help to answer our third research question about mulch's effect on soil moisture. Students first explore, build, and test virtual circuits using the online computer model from PhET at the University of Colorado, Boulder. They then learn about how a soil moisture meter works, develop a plan to build their own soil moisture sensor using a micro:bit computer.

Learning Outcomes & Assessments

<i>By the end of this module, students will be able to...</i>	<i>You can assess this using...</i>
1. Use the PhET online circuits model to build a circuit and test the conductivity of different objects.	Field notebook entry
2. Explain conductivity and resistance in the context of building a circuit.	Field notebook entry; Whole class discussion
3. Identify objects that can and cannot conduct electricity.	Field notebook entry
4. Apply what they know about circuits, conductivity, and resistance to create a plan to build a soil moisture sensor using a micro:bit computer.	Research team plan; Whole class discussion

Session Overview

Section	Description	Length	Format
Launch	Students watch a short video that introduces the topic of the day: learning about circuits in order to design a soil moisture sensor to use in the Project Crystal Code experiment.	5 minutes	Whole class
Explore	<p>Students use the circuit online modeling platform from PhET at the University of Colorado, Boulder to build a circuit and test the conductivity of different objects.</p> <p>Afterwards, students learn about the design of a typical soil moisture meter, and work in their research teams to create a plan to build a soil moisture sensor with a micro:bit computer.</p>	<p>20 minutes</p> <p>15-20 minutes</p>	<p>Individual or Research teams</p> <p>Research teams</p>
Share	Students share their soil moisture meter design with the rest of the class.	5-10 minutes	Whole class
Reflect	Students reflect on their experience during Session 5.	5 minutes	Individual

Overview of the Soil Moisture Sensor Project

In Sessions 5-7 of Project Crystal Code, students will be tasked with designing, coding, and building their own environmental sensors that can measure the amount of water in the soil in our mulch treatments. Although this part of the program is optional, it offers an opportunity for participants to practice computational thinking and coding skills while developing a deeper understanding of the environmental system.

Why We Do This

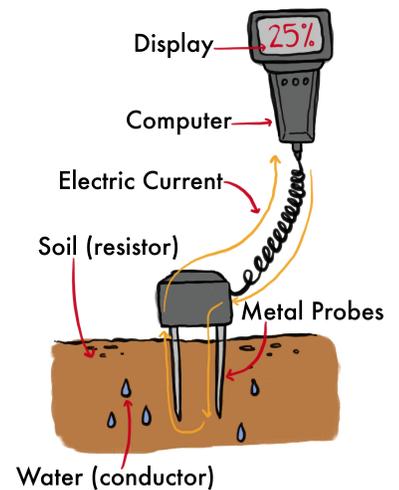
One component of systems thinking is being able to identify and understand invisible parts of the system. By building and coding their own soil moisture sensor from scratch, students will develop a better understanding of what they're measuring -- and thus how invisible parts of the system work -- than if they simply used a provided soil moisture meter.

This project also offers the opportunity for students to be introduced to block-based coding in the context of solving a real-world environmental problem. Often, coding and computational thinking is taught in isolation from other scientific disciplines. It is our hope that by integrating coding into an environmental science program, we will be able to both help students see how computer science skills have become an important part of scientific work, while also inspiring interest in coding amongst students who might not normally choose to take a traditional computer science class.

How a Soil Moisture Sensor Works

A soil moisture sensor uses two metal probes that are inserted into the soil. The sensor's computer then sends out an electric current which runs down one probe (the output) and crosses through the soil to the other probe (the input).

Since dirt itself is not usually conductive, electricity can't pass through it if there is nothing else present. However, the nutrients and minerals in the soil are conductive when water is present, allowing electricity to pass through those. This means that when you try to run a current through soil, the soil itself acts like a resistor, reducing the strength of the current. The soil moisture sensor measures the resistance between the two metal probes. The soil moisture meter's computer can then take that resistance and convert it into a reading, telling us what percentage of the total soil is made up of water.



Building a Student-Friendly Soil Moisture Sensor

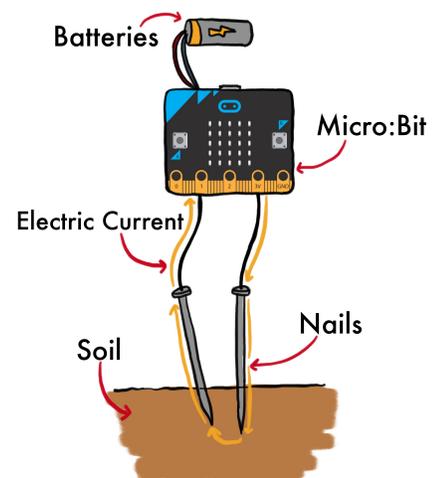
By the end of Session 7, students will design, code, and (optionally) build a soil moisture sensor using a micro-computer called a **micro:bit**. This micro-computer is similar to an Arduino or Raspberry Pi, and was built specifically for education by the British Broadcasting Corporation and Microsoft. It uses a block-based coding system, and its coding platform can be accessed for free on [Microsoft's MakeCode website](https://www.microsoft.com/makecode).

Micro:bit kits cost about \$20 each, but students can come up with a plan to build one and practice writing code online even without a physical kit. In addition to a micro:bit kit, students will also need two metal probes (i.e., nails) and two sets of wires with alligator clips. A full supply list is included below.

Each student team soil moisture kit includes:

- 1 micro:bit
- 2 AAA batteries (Included with Micro:Bit kits)
- 2 Galvanized Nails
- 2 wires with alligator clips

If you are interested in integrating the micro:bit lessons in your classroom, Crystal Cove Conservancy has classroom sets of micro:bits that are available for loan for local schools. Please contact kaitlin@crystalcove.org with any questions!



Where Today's Session Fits In

During Session 5, students will explore the concepts of circuits, conductivity, and resistance using an online simulation. They'll then be introduced to how soil moisture sensors use circuits to measure resistance. Afterwards, they'll work in their research teams to draw a schematic that applies their understanding of circuits to build a soil moisture sensor using a micro:bit computer.

The goal of Session 5 is to help students develop an understanding of how soil moisture sensors work. Later, when they begin using block-based code in Sessions 6 and 7 to write a program, this will help them contextualize the code that they write so that they understand what they're telling the micro:bit computer to do.

Throughout all three sessions, it is important to remind students of the ultimate goal so that the sessions don't feel disjointed from the rest of the Project Crystal Code program. By learning how to build and code a soil moisture sensor, we will be able to measure how much moisture is in the soil, allowing us to test our hypothesis about how mulch affects soil moisture.

Session 5		Session 6	Session 7	
<i>Exploring circuits, conductivity, and resistance</i>	<i>Designing a plan to physically build a soil moisture sensor</i>	<i>Practice block-based coding skills</i>	<i>Writing a block-based program to turn a micro:bit computer into a soil moisture sensor</i>	<i>Assembling the soil moisture sensor, downloading the code, and testing it (optional)</i>

You are here!

Virtual Materials

- Session 5 Google Slides Presentation: <http://bit.ly/3a45AN5>
- Session 5 Field Notebook Template (optional): <http://bit.ly/3tBQkPn>
- PhET Circuit Construction Kit: <http://bit.ly/3rAXsJU>

Each student will need...

- A device with internet access (a computer, smartphone, or tablet will all work!)
- Field notebook and pencil

Before You Start Teaching

- Copy over the [Session 5 Slideshow](#) for your chosen platform to your own Google Drive account. Test to make sure that the videos work. (If not, you may have to check the permissions on the Crystal Cove Conservancy Youtube Account.)
- Take a few minutes to explore the PhET Circuit Construction kit. The platform is extremely student-friendly and easy to use, and instructional videos are embedded within the slideshow. For direction on getting started with the PhET Circuit Construction kit, and watch the videos in [Slide 5](#), [Slide 9](#), and [Slide 11](#).
- Decide how you want students to work on the PhET Circuit Construction Kit. Students can work independently or in their research teams. If students work virtually in teams, one student will need to share their screen with the others and be in charge of manipulating the platform.
- Decide how you want students to draw diagrams during this session. They will need to create two diagrams during the session: a diagram of a circuit ([Slide 8](#)) and of their design for a soil moisture meter ([Slide 16](#)).

Students can sketch their design on a physical sheet of paper, use the drawing tool in Google Docs, or use another online whiteboard tool of your choosing. If you'd like them to use the Google Drawing tool, the video on [Slide 7](#) gives a demonstration of how to use this feature.

Learning Sequence

Launch

Getting Started (5 minutes)

1. Open the [Session 5 Slideshow](#) and play the video on [Slide 2](#) for your class. In this video, Kaitlin will briefly introduce Session 5 and the task for the next three sessions, which is to design and build a soil moisture sensor that can be used at our Project Crystal Code research site.
2. After watching the video, move on to [Slide 3](#), which gives an overview of what students will do and learn during Session 5.

Explore

Part 1: Exploring Circuits (30-35 minutes)

1. Advance to [Slide 4](#) and play the video. Kaitlin introduces a soil moisture sensor and explains the basics of how they work using circuits. After, she introduces students to their first task, which is to spend some time exploring how circuits work.

Take a moment and ask your students what they know or remember about circuits and how they work. They may have built circuits before using a battery and a lightbulb.

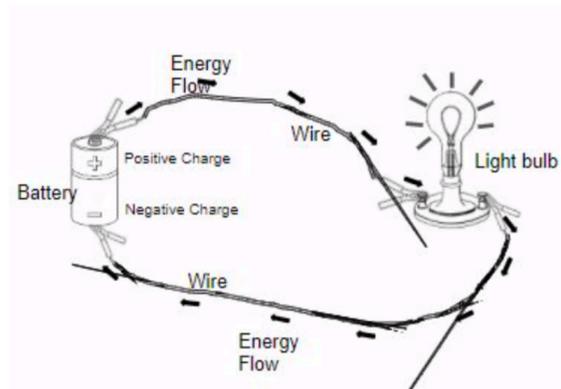
2. Advance to [Slide 5](#), where Kaitlin gives a brief introduction to how to use the PhET circuit building kit. She asks students to start by clicking on the *Intro* option on the left. She then demonstrates how to drag, connect, and disconnect the different virtual elements, and how to change the representation of the current. (You can decide if you want to give students specific directions on whether to represent the current as energy flows from negative to positive, which is the traditional option, or if you want them to use the electron representation, which flows in the opposite direction.)

At the end of the video, Kaitlin challenges students to use the PhET platform to build a circuit that causes the lightbulb to turn on.

3. Move on to [Slide 6](#) and share the link with students. As students open up the PhET website on their computers, challenge them to try to build a circuit that makes the light bulb turn on. Give them 2-3 minutes to start playing with the platform.

4. Once students have successfully built a virtual circuit that makes the light bulb turn on, move on to [Slide 7](#). Kaitlin will show students how to draw a model of how their circuit works using the Google Drawing tool. (If you prefer to have students draw their schematics using a different platform, you can skip this video and simply give them oral instructions.)

5. Advance to [Slide 8](#) and ask students to spend a few minutes drawing a diagram of their virtual circuit. They should make sure to label the different parts and show how electricity moves through the circuit. Give students a few minutes to complete their drawings.



6. When students have finished their diagrams, move on to [Slide 9](#) and play the video. Kaitlin introduces the idea of conductivity and explains that we can use the Circuit Construction Kit to virtually test the conductivity of different materials.

7. Advance to [Slide 10](#) and play the video. Here, Kaitlin demonstrates how to switch over to the Lab view in the Circuit Construction Kit, which gives students more items to explore. She shows them how to drag objects onto the lab space and test their conductivity, then directs them to explore what materials are and are not conductive.

8. Once the video is done, move on [Slide 11](#). Ask students to set up their field notebook with a simple table so they can keep track of which objects are conductive and which are not conductive to electricity.

9. Once students have set up their field notebooks, give them a few minutes to test the conductivity of different objects in the PhET model. Encourage them to record their results in their field notebook.

As students work, ask them how they can tell if an object is conductive or not. What happens to the lightbulb when you have an object that is more conductive or less conductive?

Item	Material	Is it Conductive?
Paper Clip	Metal	Yes
Coin	Metal	Yes
Hand	Meat	No
Dog	Dog things	No
Eraser	Rubber	No
Dollar Bill	Paper or fabric	No
Pencil (sharpened on both ends)	Graphite	Yes

10. Finally, move on to [Slide 12](#) and play the last video to introduce the idea of resistance and resistors.

11. Advance to [Slide 13](#) and give students a minute to try adding a resistor into their circuit. Ask them to respond to the questions on the slide in their field notebook:

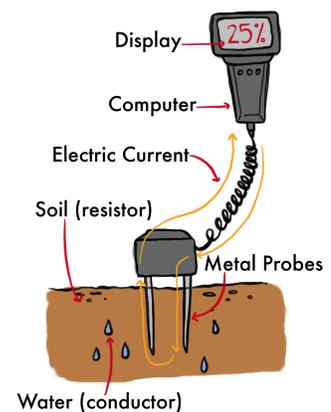
- Based on your exploration with the Circuit Construction Kit, what can happen if the energy source (or battery) in a circuit is too powerful?
The light bulb can shine too brightly or sometimes catch fire.

- What is an electrical resistor? What does a resistor do when you add it to a circuit?

Electrical resistors slow down the flow of electric currents. When added to a circuit it slows down the flow of energy to provide less power to the lightbulb.

Part 2: Designing a Soil Moisture Sensor (15-20 minutes)

12. Once the students have completed the circuits investigation, play the video of Kaitlin on [Slide 14](#) to introduce the next task: students will use what they've learned about circuits, conductivity, and resistance to design a soil moisture sensor.

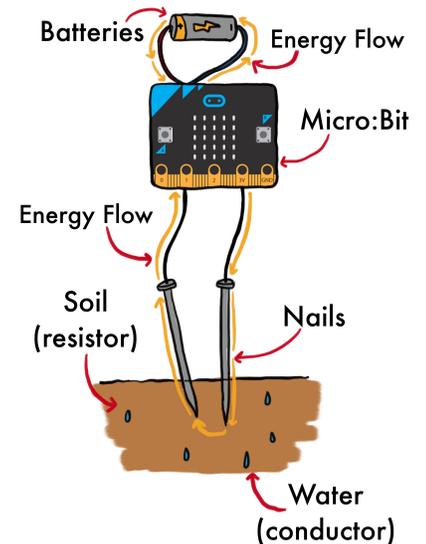
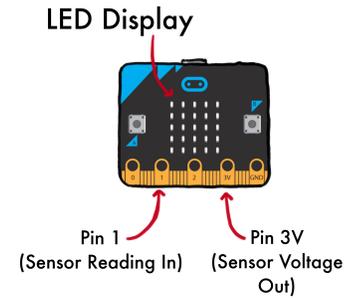


13. Advance to *Slide 15* where Kaitlin will explain the components of a soil moisture sensor and how they use conductivity and resistance to measure soil moisture.

14. Next play the video on *Slide 16*, which explains what a micro:bit computer is and how it can take in electrical readings from a sensor and display them on a screen.

15. Move to *Slide 17*, and split the students in their research teams. Ask students to use what they now know about circuits and micro:bit computers to draw a diagram in their field notebooks showing how they could build a soil moisture meter!

Give students about ten minutes to work. As possible, circulate between the groups to listen to their plans and offer suggestions as necessary.



Share

Sharing Our Plans (Optional) (5-10 minutes)

1. Bring the research teams back together as class, open *Slide 18*, and have each group share their design for a soil moisture sensor.

Reflect

Reflecting on Session 5 (5 minutes)

1. At the end of the discussion, advance to *Slide 19* in the slideshow and play the video, where Kaitlin will invite them to spend a few minutes reflecting.

2. Advance to *Slide 20*, which will share reflection questions. Ask students to spend five minutes reflecting on their experiences today in their field notebook.

3. Finally, thank the class for their time today. Tell them that when you gather again, they will learn more about how to code the micro:bit computer so that it can display our soil moisture readings.