Crystal Cove® CONSERVANCY

Session 5: Building a Circuit

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

Systems Thinking Characteristics

- Identifying Hidden Dimensions of the System
- Constructing Explanations and Designing Solutions

In the fifth session of Project Crystal Code, students learn about conductivity by creating circuits using alligator clips, batteries, and lightbulbs. Students will then use their understanding to build a soil moisture sensor.

Students are introduced to their task for the next three sessions: to design and code a sensor that can measure soil moisture. After the introduction, students are split into their research teams and given an Energy Ball or Energy Tube. Students will learn about conductivity by experimenting with how they can light up the Energy Ball/Rod. Once students complete this activity they'll use what they learned to build a functional circuit with lightbulbs, alligator clips, and batteries. Their goal is to create a circuit that is able to light up the lightbulb. Lastly, they will learn how a soil moisture meter works, and develop a plan to build their own using a micro:bit computer.

Learning Outcomes & Assessments

By the end of this module, students will be able to...	*You can assess this using...*
1. *Use* alligator clips, a light bulb, and a battery 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 built 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	Students use energy balls/rods to learn about how electricity can be conducted through a circuit.	5-10 minutes	Research teams
	Students use light bulbs, alligator clips, and batteries to create a working circuit and test the conductivity of different objects.	15-20 minutes	Research teams
	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.	5-10 minutes	Research teams
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 different plant type 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.

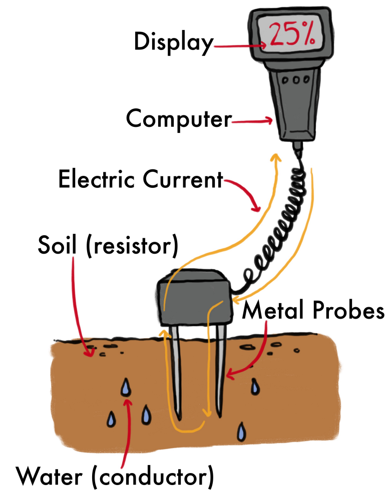
Why We Do This

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

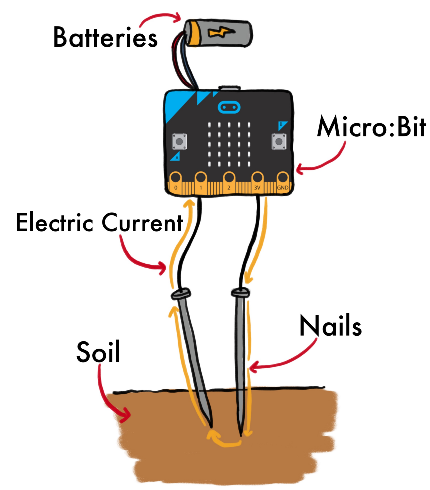
A soil moisture sensor uses two metal probes that are inserted into the soil. The sensor's computer then sends out an electric current which runs down one probe (the output) and crosses through the soil to the other probe (the input).



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 Arduinoor 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***.



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 ***georges@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 a circuit kit. 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 plant types affect soil moisture.

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

You are here!

Materials

- ***Session 5 Google Slides Presentation***
- ***Session 5 Field Notebook Template (optional)***

Each student will need...

- Field notebook and pencil
- Circuits Kit with the following materials:
  - (1) Energy rod
  - (1) D-cell batteries
  - (1) battery holds
  - (2) electrical wires with alligator clips
  - (1) light bulb
  - (1) light bulb socket

You can source these materials online but we are also happy to provide our pre-made circuits kit. If you are interested in physically modeling a circuit with your students, Crystal Cove Conservancy has classroom sets of physical circuit kits that are available for loan for local schools. Please contact ***georges@crystalcove.org*** with any questions!

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.)

- Review the supplies in the Circuits Kit and come up with a plan to distribute them to students.

- Decide you want to source your own parts for the Physical Circuits Kit or require a loaned kit. If you choose to use a loaned Physical Circuit Kit please reach out to us so we can loan you the materials needed to complete the activities.

- 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 10***) and of their design for a soil moisture meter (***Slide 19***).

  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 10*** gives a demonstration of how to use this feature.

Learning Sequence

Launch

Thinking About How to Measure Soil Moisture (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. Kaitlin introduces students to the energy rods and then challenges them to find all the different ways they can to make the energy rod light up and make sounds.

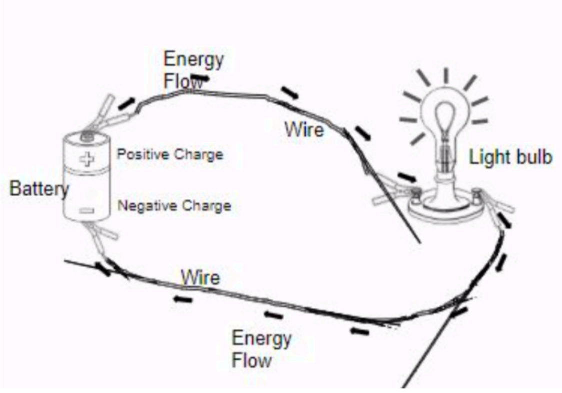
Take a moment and ask your students what they know or remember about circuits and how they work. They may have built circuits before using a battery and a lightbulb.

2. ***Slide 5*** contains a table the students can draw on their field notebook along with simple instructions with that to use it for. As students explore with the energy rods, encourage them to try to find as many ways as possible to make the rod light up. How many students can they involve? How about using a notebook or a desk as part of the circuit?

3. Move on to ***Slide 6*** where Kaitlin asks students to reflect on their experiences with the Energy rod/ball, it prompts them to reflect on what caused the Energy rod/ball to light up and what failed to. After, Kaitlin uses this reflection as a springboard to introduce the concept of a circuit and explains how our body served to create a circuit. She finishes by instructing students to build their own circuits.

4. ***Slide 7*** directs students to start building their physical circuits. Distribute the circuits kit with alligator clips, batteries, and a lightbulb to each team and give them time to make the lightbulbs shine.

5. Advance to *Slide 8* and play the video. In it Kaitlin asks the students to spend a few minutes drawing a diagram of their physical circuit and shows them how to do so using google drawing tool.



6. Move on to *Slide 9* and ask your students to draw a diagram of their circuit. They should label the different parts and show how electricity moves through them. Give students a few minutes to complete their drawings.

7. Advance to *Slide 10* and watch the video, where Kaitlin shows the students her circuit, along with common classroom finds like paper clips and notebooks. She invites them to test what objects are conductive enough to cause the light bulb to light up when connected to the circuit. Once your students finish watching the video, move to the next slide.

8. *Slide 11* has a table design students can use to keep track of objects' conductivity as they experiment with different materials in their Circuit Kits.

Once students have set up their field notebooks, give them a few minutes to test the conductivity of different objects in the physical circuit. 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
Eraser	Rubber	No
Dollar Bill	Paper or fabric	No
Pencil (sharpened on both ends)	Graphite	Yes

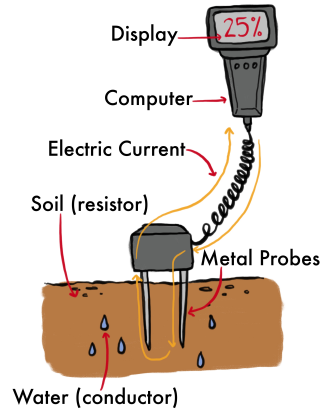
9. Finally, move on to ***Slide 12*** and play the video. In this video, Kaitlin introduces students to the idea of *resistance* in electrical circuits and what resistors do! Kaitlin then builds on the student's experiments in the last slide and explains how resistance plays an important role in understanding soil moisture meters. After the explanation, Kaitlin asks students to go to the next slide and checks for understanding by having the students answer questions in their field notebooks.

10. Advance to ***Slide 13*** and ask students to reflect on what they have learned on resistance and resistors and ask them to respond to the questions on the slide in their field notebook:

- What is an electrical resistance?
  Resistance is a measure of force acting against an electrical current.

- What does a resistor do?
  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 parts of the circuit.

- How does soil moisture impact electrical resistance?
  Because soil itself is not conductive, electricity can't pass though it. However, the nutrients and minerals in the soil ARE conductive when water is precent, so electricity can pass through them. This means that in dry soil a current will encounter more resistance as it moves, while in wet soil it will encounter less resistance.



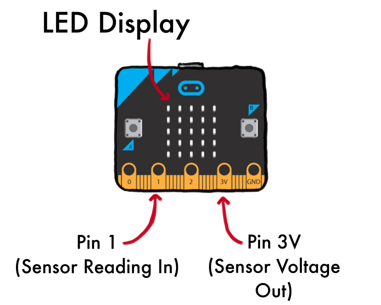
- How is electrical resistance used to measure soil moisture?
  A soil moisture meter releases an electrical pulse into the ground and records the amount of resistance the electrical pulse encounters. Its computer then converts this measurement into a reading telling us what percentage of the total soil is made up of water.

Explore

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

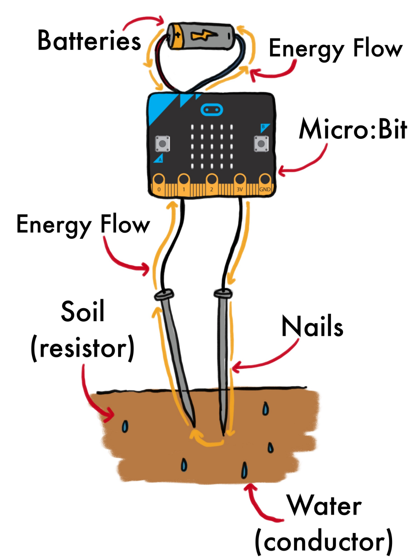
1. Once the students have completed the circuits investigation, play the video of Kaitlin on ***Slide 14*** to introduce the next task: students will use what they've learned about circuits, conductivity, and resistance to design a soil moisture sensor.

2. 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.



3. 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.

4. 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.