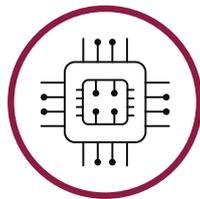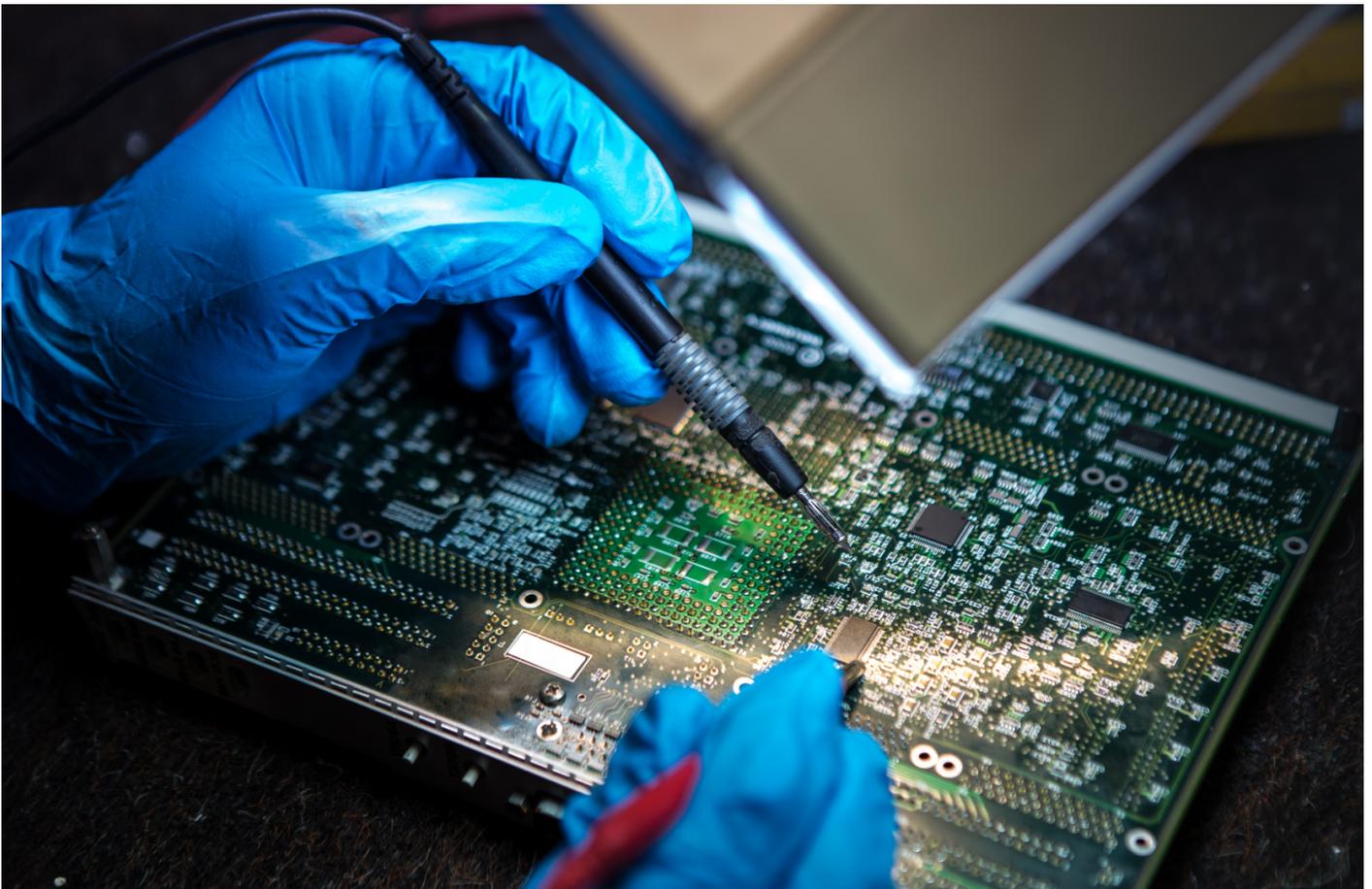# CENTER FOR THE FUTURE OF ARIZONA

SEMICONDUCTORS

Lesson 1: Introduction to Semiconductors

Facilitator Guide
How to Prepare for This Lesson

Table of Contents

About This Facilitator Guide

This facilitator guide provides instructors with the information needed to guide students through the digital version of Introduction to Semiconductors.

Before You Get Started

Before you get started with this lesson, please be sure to do the following:

- Read through the facilitator guide
- Review the Rise lesson
- Prepare any resources needed for the lesson

Using Editable PDFs

Most lessons include using an editable PDF for students to capture responses to questions and other activities.

Guiding language is included in the lesson to help students access and use the editable PDFs where they appear.

Students who will be using Chromebooks will need to use the Print to PDF function to save their editable PDFs to their devices. Here's how to do this:

1. Open the editable PDF and select Ctrl + P.
2. Open the file destination where the file will be saved.
3. Select "Save as PDF."
4. Select "Print." Your document is now "printed" as a PDF file, which will save your work.

PDFs cannot be submitted via the Rise interactives. If you plan to collect these documents for career planning portfolios or grading, you will need to coordinate that with your students.

Unit Overview and Alignment of Learning Targets

This unit contains five lessons, as follows:

- Lesson 1: Introduction to Semiconductors
- Lesson 2: The Magic of Raw Materials and Design
- Lesson 3: Fun With Front End Design and Machinery
- Lesson 4: A Beginner's Guide to Back End Assembly and Functions
- Lesson 5: The Future of the Semiconductor Industry and My Place in It

For students to get the most value from this unit, please plan on implementing all lessons in this unit in sequential order.

Tracking Completion of Lessons

If you are using SCORM Cloud or Canvas with the lessons in this unit, completion tracking options are available. If you are not using either platform, please determine if and/or how you plan to track the completion of lessons by the students.

Lesson 1: Introduction to Semiconductors
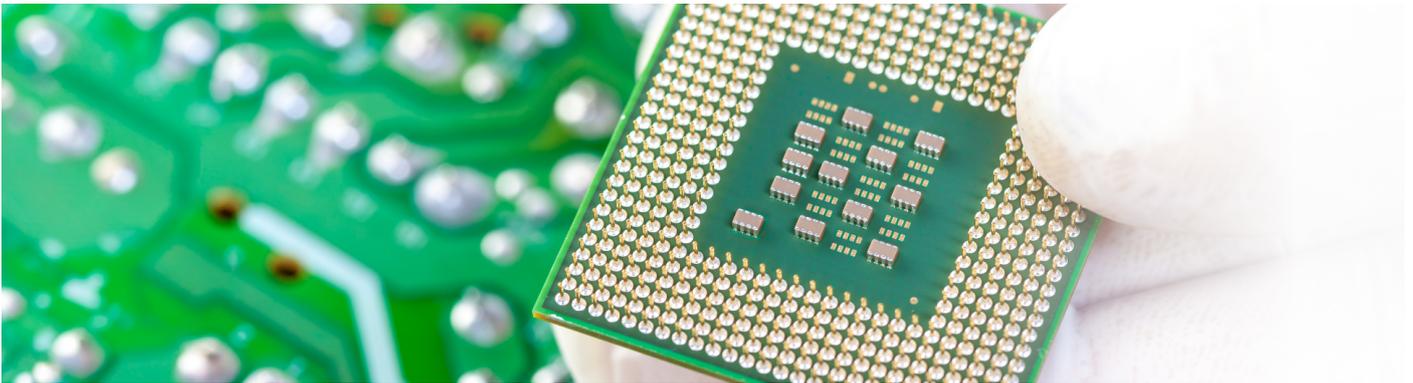
🖾 Lesson 1 Components

🕐 Pacing

The lesson is designed to extend over multiple class periods to build the background knowledge students need to explore careers and to be able to answer the lesson's guiding question. You may tailor the lesson to meet the needs of the class. If you choose to teach the lesson in its entirety, plan where you will stop after each session. Prepare an appropriate debrief for that class and a way to reengage students in the activities for the next class session.

📄 Materials

N/A

Be sure to review any Extension Activities that may be suggested at the end of this lesson and consider when and how your students will complete them.

Guiding Questions

The guiding question is intended to provide a focal point for each lesson. This lesson's guiding questions are as follows:

- What are semiconductors, and why are they important to me?

Lesson Overview

This lesson will introduce the history of semiconductors and show what they are, what they do, and why they're important to us. You will see how computers work using circuits and logic. Then, you will explore where semiconductors can be found in our daily lives. Finally, you will take a look at the types of careers that can be found in the semiconductor industry. You even get to take a survey that will match your interests with those career paths.

Vocabulary in This Lesson: Flip Card Activity

The flip card activity is designed to familiarize students with key vocabulary terms and definitions for this lesson. These vocabulary words are bolded throughout the lesson. Students must flip each card to proceed with the lesson.

Semiconductor:
A material that conducts electricity under some conditions and not others. This is similar to a traffic signal at a busy intersection. It can stop the vehicles (blocking) or let them go through the intersection (conducting).

Switch:
A device that reroutes a system or turns it on or off. This is exactly like the light switches in a classroom that can turn the lights on or off. Switches come in all shapes and sizes and can be found everywhere.

Electrical Signal:
The measurable movement of electromagnetic waves through a conductor (copper, gold, etc.), which can be routed or amplified to perform a function. The electrical signal is like the water that runs through a pipe. The movement of the water can change direction or can be used to produce motion if you put a fan in the pipe.

Amplify:
To increase the value of an electrical signal. When increasing the volume on a phone or TV, the signal that produces the sound is being amplified.

Transistor:

A semiconductor device that can be used to switch or amplify an electrical signal. A transistor is like a nozzle on a hose. By lightly squeezing the handle, the water can be turned on or off. By squeezing harder, more water will flow (amplify), and when easing up, the flow of water is reduced.

Microchip:

A set of electronic circuits on a flat piece of silicon, also called a chip, a computer chip, an integrated circuit, or an IC. Your brain takes in information and sends messages to your body; for example, when you touch a hot surface, it tells you to pull your hand away. Similarly, a microchip takes in information and sends messages to other electronic devices to perform the action.

Learning Targets

By the end of this lesson, students will be able to do the following:

- Describe the history of semiconductors
- Explain the purpose of semiconductors
- Identify common uses for semiconductors in everyday life

The Invention That Changed the World

In this section, students will be introduced to the topic of semiconductors. As a facilitator, you can either watch the video for self-reference or show it to the entire class as part of the introduction.

The History of Semiconductors

In this section, students will review the history of semiconductors from 1906 to the present. The information is presented in a Rise course component called a timeline block.

You can also share the following additional resources with the students:

Additional Resources

- https://www.semiconductormuseum.com/Museum_Index.htm
- ENIAC computer parts available for viewing at the University of Pennsylvania: https://commons.wikimedia.org/wiki/File:ENIAC_Penn1.jpg

The Purposes and Uses of Semiconductors

In this section, students will review key vocabulary terms by flipping each card to proceed with the lesson.

Logic Gate: An electronic circuit designed to take in a 1 (on) or 0 (off) electrical signal and output a 0 or 1 based on a truth table. Logic gates are like a series of locks on a door. By turning the locks one way (on) or the other (off), the door can be opened.

Truth Table: A table of 1s and 0s showing the required output of a specific logic gate. The truth table is like the recipe for a logic gate. It tells the engineer what they should get out of the gate if specific ingredients (pairs of 1s and 0s) are input to the gate.

The students will then explore the following subtopics: how computers perform computations using logic functions and the various semiconductors students use in their daily lives.

How Computers Work: Circuits and Logic

In this section, students will watch a video on how computers perform computations using logic functions.

Where Do We See Semiconductors Today?

In this section, students will explore the various semiconductors used in their daily lives. A graphic character named Sami the Semiconductor will introduce the topic and guide students through the content. The information is presented in a Rise course component called a process block. Students can navigate through the steps or sections by selecting the arrows on the left or right side of the process block.

💬 Let's Talk About It

In this section, students will reflect on the following questions about the uses of semiconductors. This could be a full class, a small group, or a pair-and-share discussion.

The students will use the editable PDF to respond to the following questions:

- What would be different today if semiconductors didn't exist?
- How can switches be used to perform calculations?
- How can a semiconductor device improve the lives of people?

Careers in the Semiconductor Industry

In this section, students will first review the following key vocabulary term by flipping the card to proceed with the lesson:

Supply Chain: The series of materials suppliers, manufacturers, distributors, shippers, and so on involved in producing specific goods and bringing them to market.

The students will then explore various career opportunities in the semiconductor industry using a Rise component called a carousel. Students can use the arrows to navigate through and review each career option available in the semiconductor industry.

The students will use the editable PDF to respond to the following questions:

- What would be different today if semiconductors didn't exist?
- How can switches be used to perform calculations?
- How can a semiconductor device improve the lives of people?

Explore Your Interests

In this section, students will watch a video that guides them on how to find the correct survey on the semi.org website. If needed, guide the students to select the link to discover how their interests can lead to a future in semiconductors.

Focus Your Interest

In continuation of the previous exercise, students will select one or more careers that they find interesting from those matched by the survey.

The students will use the editable PDF to respond to the following questions:

- What is it about these careers that you find interesting or cool?
- What surprised you about these careers?

Thinking About Your Future

Students will see the following statement in Rise: In this lesson, you explored a career in the semiconductor industry.

Before moving on to the next lesson, take some time to reflect on these questions:

- Was there anything that surprised you about where you can find semiconductors?
- What jobs in the semiconductor industry sound interesting to you?

Career Pathways

Share the following with your students: It's never too soon to start exploring future career options!

Students can access the resources at this link: Pipeline AZ

Lesson Completion

At the end of the lesson, students will see the following message in Rise:

In future lessons, you will learn about different aspects of the semiconductor industry. Topics will include raw materials and front end design, photolithography and etching, and packaging and back end design.

Extension Activity

Build a logic gate (and/or) with a battery, LED, and switches to experience how they work.

Materials

- Push-button switches (They can be purchased here: push-button switches. Amazon sells them in packages of 150 for $6.99; each student will need two.)
- LED lights (They can be purchased from Amazon: LED lights. Amazon sells packages of multicolor LEDs for 11.99 for 450 pieces.)
- Mini breadboards (They can be purchased in 48 packs from Amazon for $19.99 at mini breadboard 48 pack or in 12 packs for 7.99 from Amazon at mini breadboard 12 pack.)
- AAA battery holder compatible with breadboard (A 20-pack can be purchased from Amazon for $6.99 here: AAA battery holder.)
- Breadboard wires (A large pack can be purchased here for 13.99 for 840 pieces here: breadboard wires.)
- AAA batteries (They can be purchased anywhere. Amazon sells multipacks for between $12 and $20. Amazonbasics batteries can be purchased here: Amazonbasics batteries.)
- Wire strippers (Only one is necessary for the teacher to strip the leads on the battery holders; a decent one can be purchased on Amazon here: basic wire stripper.)
- Sharpie

Prep Before Lesson

1. Strip half an inch of the plastic sleeve from the battery holders to expose the wire. If the facilitator understands soldering, it can be helpful to tin the ends of the battery holder sleeve to make it easier to insert into the breadboard, but this is not required.
2. Each student will need five wires. It could be helpful for each student to have a nice mix of longer and shorter wires. Some students find it easier to use longer wires as it is easier to insert them into the breadboards.
3. Print the page with the diagram and truth table for the "or" and "and" gates for each student.

Vocabulary

Logic Gate: An electronic circuit designed to take in a 1 (on) or 0 (off) electrical signal and output a 0 or 1 based on a truth table. Logic gates are like a series of locks on a door. By turning the locks one way (on) or the other (off), the door can be opened.

Truth Table: A table of 1s and 0s showing the required output of a specific logic gate. The truth table is like the recipe for a logic gate: It tells the engineer what they should get out of the gate if specific ingredients (pairs of 1s and 0s) are input to the gate.

Boolean Algebra: A form of mathematics that performs calculations using binary numbers instead of decimals. This allows calculations using only 1s and 0s instead of 1–9. Calculations using 1s and 0s can be done using switches.

Questions to Ask Before the Activity

1. How do you think semiconductors can perform calculations?
2. Have you ever wondered how your calculator works?
3. Can you perform calculations with a circuit?

A Note for Instructors

Breadboards are like miniature versions of the outlets in your house. You simply plug the wires into the slots, and you can connect the circuit. The rows designated by numbers are all on the same electrical path (they are all connected), and the holes in the rows designated by letters are all on different electrical paths. By connecting wires on the numerical rows, all of those wires are the same as if they were tied together. Students need to build the circuits as shown in the diagram. The green lines on the

diagram show where the wire should be plugged in first and where it should end. When the circuit is done, it should look identical to the diagram.

Procedure

1. Explain to students that semiconductors perform calculations using Boolean algebra. This is a kind of math that allows us to do calculations using only values of 1 or 0. This means that we can perform calculations by turning switches on or off. Explain that today students will be creating two of the basic circuits used to perform these calculations. These circuits are called logic gates.
2. Before starting, explain to students that they will be working with electricity and any time they work with electricity they need to be careful so that they are not shocked. They will be working with very low voltage (AAA battery) so there is a very low risk, but they can still shock themselves. They need to follow the directions given to them by their instructor.
3. Hand each student a breadboard, an LED, two switches, a battery, a battery pack, and a small pack of wires.
4. Explain the difference between an anode and a cathode on a diode. Explain that the long lead is the anode, and the short lead is the cathode. If the LED is connected in the wrong direction, it will not light up and it can be damaged. The image shows the angled lead as the long lead or the anode.
5. Instruct students to build the circuit shown for the OR gate in the image by first connecting the switches and the LED.
6. Check the student's circuit.
7. After the circuit is built, connect the battery's positive lead first and then the negative lead.
8. Next, have the students press the buttons, first one, then the other, and then together. Discuss whether the LED lights up. Do they match what is written on the table?
9. Give the students time to play with their OR gate. Ask questions about what they observe.
10. Have the students disconnect the battery, the negative lead, and then the positive one, and then remove the wires from their circuit. (Leave the LED and switches.)
11. Instruct the students to connect the circuit shown for the AND gate in the image using their wires.
12. Check the student's circuit.
13. Connect the battery's positive lead first and then the negative lead.
14. Have the students press the buttons, first one, then the other, and then together.

Discuss whether the LED lights up. Do they match what is written on the table?

15. Give the students time to play with their gate. Ask what they observe.
16. Have students disconnect their batteries, and then disassemble their circuits and return their components.

Questions to Ask After the Activity

1. How easy was it to build your circuits?
2. How did your OR gate work? What happened when you pressed each button?
3. How did your AND gate work? What happened when you pressed each button? Was this different from the OR gate? How?

Thinking About Your Future

Talk to students about what interested them about this activity. Explain that different kinds of engineers do different things when designing these kinds of circuits. Computer Engineers may design the logic gates, Electrical Engineers may design the electrical circuits that allow the logic gates to function, and Computer Scientists create the code that determines how the gates will operate. Electricians work on circuits as well; only their circuits are usually much larger and typically have to do with the battery part of the system and how power is transferred to the circuit.

OR Gate Diagram and Truth Table
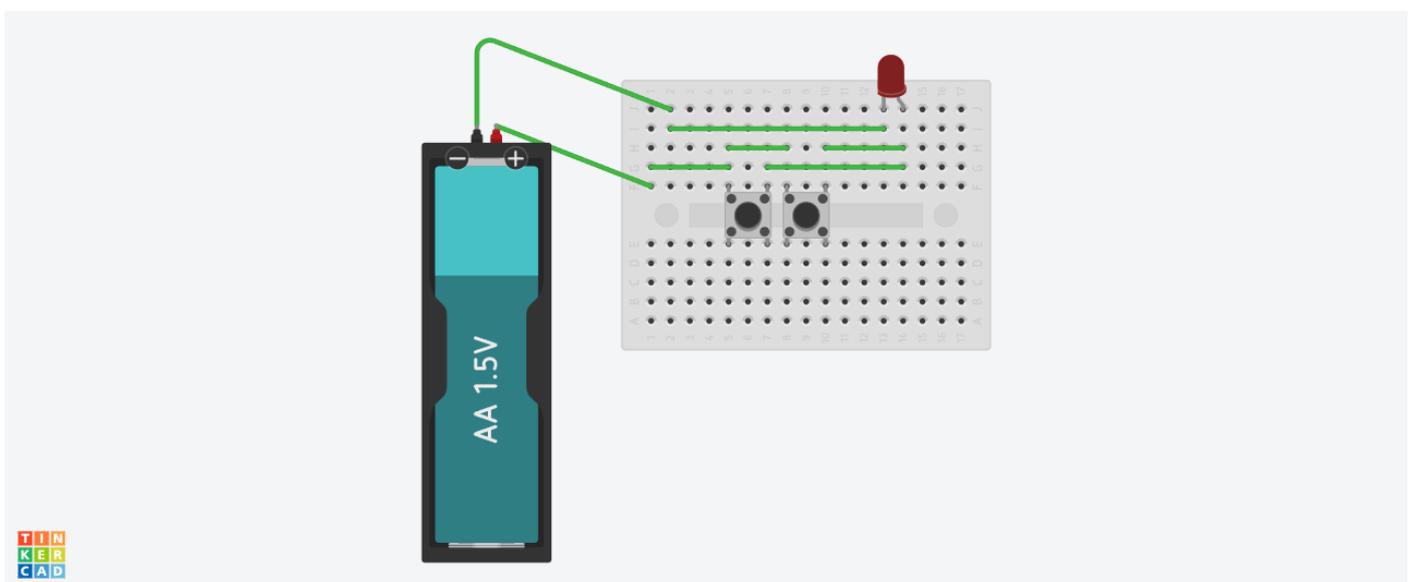
OR Gate Diagram: This diagram shows the OR gate built on a mini breadboard. Green lines show where the wires should sit and start at the first hole where the wire should be inserted and end at the second hole where the wire should be inserted. Tinkercad only has a four-wire push-button switch, so the two wires will need to be inserted in the two holes above the gap in the breadboard.

An OR gate turns the LED on when either one of the switches is pressed in. A truth table shows a 1 if the LED should turn on and a 0 if the LED should be off. The truth table for an OR gate looks like the following:

Switch 1	Switch 2	LED Light
Off = 0	Off = 0	Off = 0
Off = 0	On = 1	On = 1
On = 1	Off = 0	On = 1
On = 1	On = 1	On = 1