Learning About Semiconductor Technology

RUNNING AND INTERPRETING TESTS & TROUBLESHOOTING

HIGH SCHOOL ENGINEERING
HIGH SCHOOL MATHEMATICS

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Running and Interpreting Tests & Troubleshooting

Lesson Overview	Career Highlight
By engaging in a real engineering design challenge, students will be able to experience a high-stakes competition to solve their challenge through troubleshooting.	Validation Engineer Manufacturing Engineer Field Service Engineer

STEM Course Connections	21st Century Skills	CTE Alignment
High School Engineering High School Mathematics	Critical Thinking Creativity Problem Solving Collaboration	Manufacturing and Product Development

Engineering Activity	
Science and Engineering Practice	One of the most valuable skills that a student can learn before participating in a semiconductor apprenticeship is their ability to think critically and adapt to problems. Students will participate in a hands-on simulation that will enable them to run and interpret tests and troubleshoot solutions.

Materials

- Beaker/Glass (8)
- Cardboard box (3)
- Cones
- Construction Paper
- Rope (10-foot sections)
- Sailors and Coconuts Problem Printout
- Siphon tube
- Tent
- Student Handout

Essential Questions

1. How do you troubleshoot and adapt to problems that occur through the semiconductor manufacturing process?

Prerequisite Knowledge

Students should have a basic knowledge of what a microchip is, and the uses for microchips within the semiconductor industry. Recommended HTU lessons include: Introduction to Semiconductors; What are Semiconductors?; Education and Career Pathways; Semiconductor Industry Introduction + Pathways

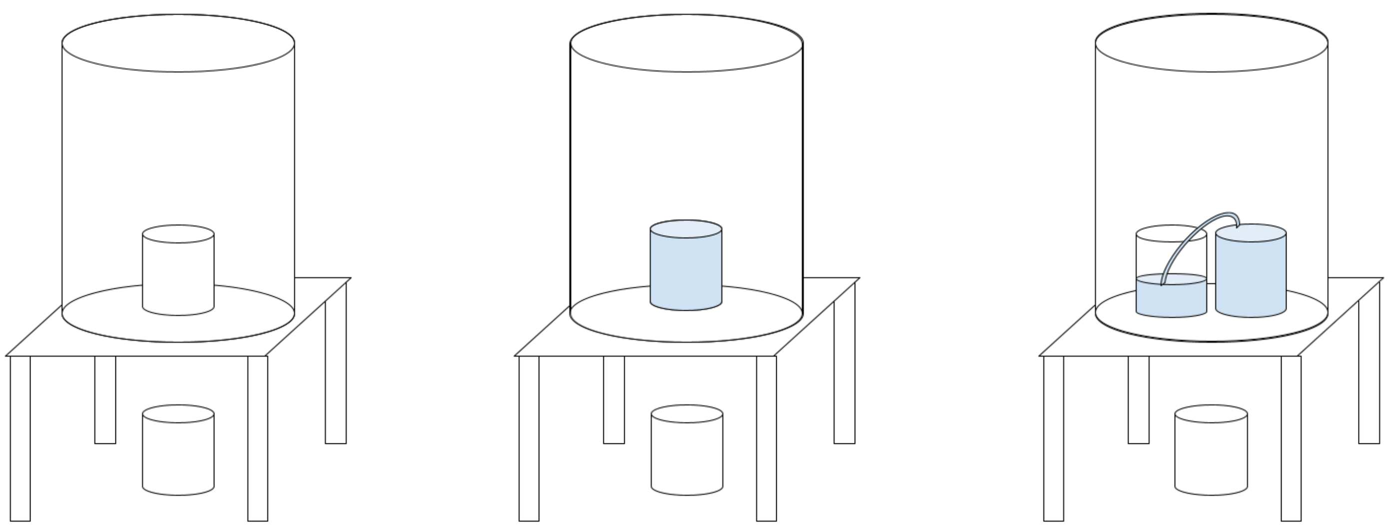
Engage

Tent Set Up (15 mins)

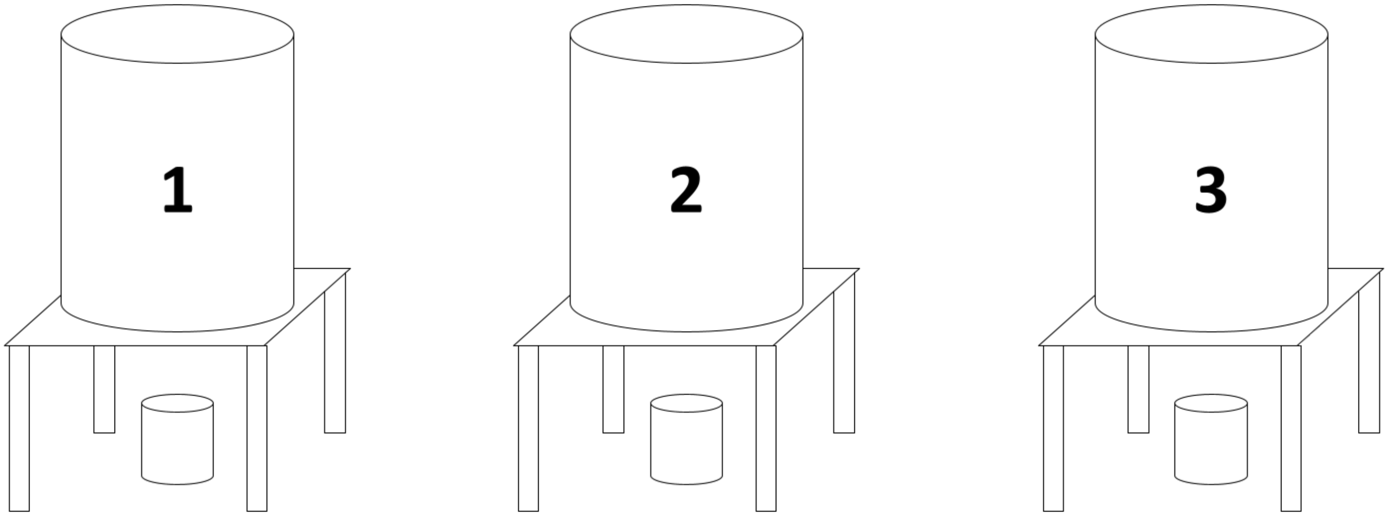
- Teacher brings in a tent for the class and withholds the instructions.
- In pairs, students will write the instructions step-by-step as they troubleshoot putting together the tent.
- This can either be done in smaller groups during rotating station teaching, or can be done as a whole class with a few volunteers who build the tent.
- Students will create their own instructions for setting up the tent in Section A of the Student Handout.
- After the class instructions are created, students will compare the instructions they made with the actual instructions provided with the tent.
- Students will answer the following questions in Section A of the Student Handout.
    - How similar are the instructions that you designed? Is there more than one way to set up the tent? *Answers will vary.*
    - What design features of the tent made it challenging to construct? *Answers will vary.*
    - Where did problem solving and critical thinking come into place during setup? *When trying to figure out the correct location or orientation for components.*

Mystery Box Design Challenge (30 mins)

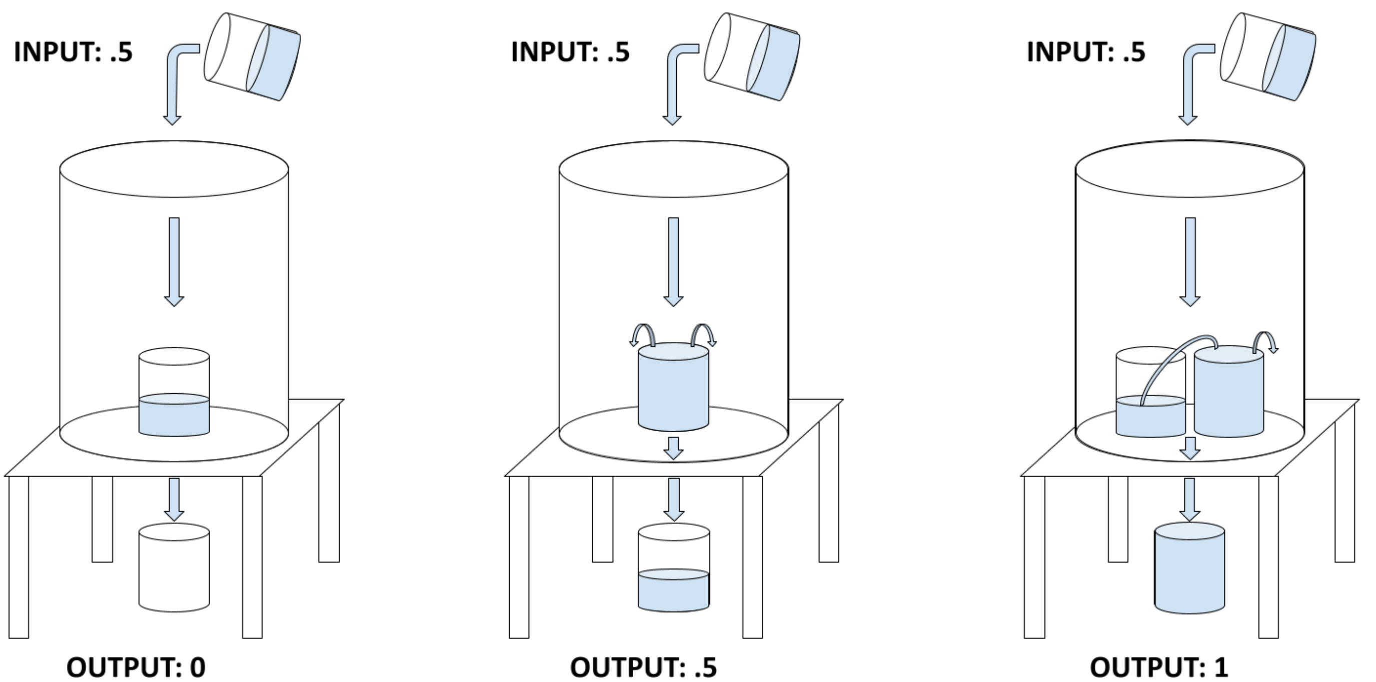
- *Teacher Note: Teachers should design their mystery boxes ahead of class. Below is a suggestion for the internal design of the box, but alternatives are acceptable as long as the input does not match the output in each of the designs. Materials for the mystery boxes can be cardboard boxes, rubber tubing for the siphon, a ring stand or other stand for the box, construction paper around the outside, etc. Use glass beakers and plastic funnels in the bottom of the mystery box to filter the water into the bottom beaker.*
- Set up the mystery boxes, but do not allow students to see the components of the inside of the box.



- The first box should have an empty beaker on the inside and an empty beaker below. The second box should have a full beaker on the inside and an empty beaker below. The final box contains one full beaker and a half full beaker and one empty beaker below. This final set should be prepped with a siphon tube in the full beaker.



- Students should only be able to see the empty beaker below the mystery box with each labeled 1-3.
- The teacher will first ask students to make a prediction for what they think will happen if a half beaker of water is poured into each of the boxes. Students will write their responses in Section B of the Student Handout.
- The teacher will pour the water into each box and students will record their observations in Section B of the Student Handout. *The first box will have no output. The second box will have an output of .5, and the third box will have an output of 1.*



- Students will then share their comments with a neighbor.
- Students will decide which amounts of liquid they would like to try to pour into the mystery boxes next so that they can use their reasoning skills to determine what the inside of the boxes look like.
- Students will then discuss as a class which test they would like to see next while the teacher resets the mystery boxes. *Teacher Note: A back room or behind a cabinet works well to hide the inside of the box during the set up.* Students record their thoughts in Section B of the Student Handout.
- The teacher allows 2 additional tests of differing volumes on each of the mystery boxes. The class must decide on the input volumes together. Students will take notes for each trial in Section B of the Student Handout.

The Sailors and Coconuts Problem (25 mins)

- Students will work in pairs to solve the Sailors and Coconuts Problem.
- Students will draft their work in Section C of the Student Handout.
- As a class, students will share various ways they solved this problem.
- Students will answer the following questions in Section C of the Student Handout.
  - What problem solving and critical thinking strategies did you use to solve this problem? *Guess and check, algebra, working backwards, etc.*

Explore

Developing Problem Solving Skills (25 mins)

- As a class, students will need to cross the "river" together by using critical thinking and problem solving skills.
- *Teacher Note: Before class, choose a location in the classroom or outside where a river can be mapped out by 2 lines, cones, or jump ropes. Cardboard pieces or squares of construction paper can be used for "rocks" and there should be enough for each student to have their own.*
- The challenge: students will need to move from one river bank to the other as a group. Each student will receive a "rock" which only they can move. However, any student is allowed to step on their rock. If anyone steps in the "river" the team must start over. When the whole team has successfully crossed the "river" using the "rocks" they have completed the challenge.
- Before beginning, allow time for students to discuss the plan for their crossing.
- Modifications: With a larger class, the river crossing activity can be done in two or more teams. Consider also adding additional challenges or obstacles, such as blind folding a student, or choosing one to two very actively participating students to no longer be able to speak.
- After the activity, students will answer the following questions in Section D of the Student Handout.
  - What was the initial strategy your team used to cross the river? *Answers will vary.*
  - What challenges did you and your team come across? How did you adapt to overcome these challenges? *Answers will vary.*
  - Who or what helped to make this river crossing possible? Why was that important? *Answers will vary.*
  - How could you use these problem solving skills in everyday life? *Answers will vary.*

The Problem with Fab Down Time (15 mins)

- Read the article [Why is fab down time a big deal?]
- Students will answer the following questions in Section E of the [Student Handout].
    - Identify the problem the article has identified with downtime in the fab industry. *Unplanned stoppages in production caused by a broken machine can lead to loss of profits.*
    - What are some potential solutions to this problem? *Scheduled inspections and frequent calibration of these highly technical machines allows problems to be identified before they can become catastrophic.*

Explain

Types of Problems in the Semiconductor Industry (10 mins)

- Students will read about some examples of [problems and solutions] in the semiconductor industry.
- In pairs, students will answer the following questions in Section F of the [Student Handout].
    - Dicing Machinery
        - How is improved productivity achieved? *High-strength components lead to reduced stabilization time.*
        - How is improved equipment accuracy achieved? *Screws with low thermal expansion.*
        - How are components prevented from loosening during vibrations? *High strength screws.*
    - Die Bonder
        - How is high-speed bonding achieved? *High gain support for less stabilization time.*
        - How are components prevented from loosening during vibrations? *High strength screws.*
    - Wire Bonder
        - How is high-speed bonding achieved? *High gain support for less stabilization time.*
        - How are components prevented from loosening during vibrations? *Fallout prevention.*
    - Mounting Machinery
        - How is high-speed bonding achieved? *High gain support for less stabilization time and lightweight to reduce the dynamic load.*
- Students will share their responses with the class.

Semiconductor Troubleshooting (5 mins)

- As a class, watch the short [video] describing the steps that are taken when a problem occurs in a semiconductor manufacturing facility.
- Students will answer the questions in Section G of the [Student Handout].
    - Why are there so many steps needed before a problem can be diagnosed? *The manufacturing facilities are located in clean space so it is important to follow protocols which can take time.*
    - Why is it important to quickly respond to any problems that occur in a manufacturing facility? *The cost for operating a manufacturing lab is very high and any delay in processing can be very costly.*

Elaborate
Troubleshooting Case Study (15 mins) ● Students will work in partners to read through the Case Study and determine how troubleshooting was conducted in this case. ● Students will answer questions in Section H of the Student Handout. ○ What was the problem identified in the case study? *There was a tool that had one of its twelve generators malfunctioning and giving too much output.* ○ What was the process taken to determine a solution? *The first step was to swap out generators. When that failed to work, a special tool was used to determine that there was a bad control board causing incorrect voltage to be sent to the generator.* ○ What was the result of the process taken? *A control board was replaced and the tool began functioning normally.* ○ Why is troubleshooting an important part of the semiconductor manufacturing process? *These are expensive and complicated machines, and replacing the entire device because one small component is malfunctioning is impossible.* ● Share answers as a class.
Evaluate
Quandary (40-60 mins) ● Students will play the BrainPOP game, Quandary. The following has been adapted from BrainPOP. ● In the game, Quandary, players make decisions that have no clear right or wrong answers, but they do have important consequences. There are four scenarios organized into episodes that take approximately 10-30 minutes to complete. If students register, their work can be saved. ● *Teacher Note: There is a 5 minute video on the Teacher's Page that shows how the game is used in the classroom.* ● In pairs or groups of three, students will move through each episode and answer the following questions in Section I of the Student Handout. ○ What if there was another colony on Planet Braxos with a different Captain? How would this impact your decisions? *Answers will vary.* ○ Why do you think it's important to understand other points of views? *If you can understand what someone else is thinking, you can communicate with them more effectively.* ○ Describe a similar problem you have had in your own life – a problem where there's no clear answer and you didn't know what to do? *Answers will vary.* ○ What have you learned from the game that would help you make decisions when you face similar problems in your own life? *Answers will vary.* ○ How might this decision-making practice help your problem-solving skills in the semiconductor industry? *It lets us know that sometimes, there might be multiple ways of approaching the same conclusion, and not necessarily one correct way.*
Extend
● For more problem-solving practice, students can participate in this employment problem solving lesson.

CA NGSS Standards

Science and Engineering Practice: Constructing Explanations and Designing Solutions
Science and Engineering Practice: Asking Questions and Defining Problems

CTE Alignment

5.1 Identify and ask significant questions that clarify various points of view to solve problems.
5.2 Solve predictable and unpredictable work-related problems using various types of reasoning (inductive, deductive) as appropriate.
5.3 Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment.
5.4 Interpret information and draw conclusions, based on the best analysis, to make informed decisions.

Resources

Advanced Energy Industries, Inc. (2022). The troubleshooting toolkit for semiconductor manufacturers. https://www.advancedenergy.com/globalassets/resources-root/data-sheets/en-powerinsight-semi-troubleshooting-case-study.pdf

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National Council of Teachers of Mathematics. (n.d.). *The sailors and coconuts problem* . https://www.nctm.org/uploadedFiles/Content/Lessons/Resources/6-8/Classic-AS-Sailor.pdf

Paye, D. (2022, March 21). *Maintenance tips to optimize semiconductor fabrication equipment*. Therma. https://www.therma.com/semiconductor-fabrication-optimization/

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Name		Date	

Running and Interpreting Tests & Troubleshooting Student Handout

Directions: Students read the prompts and answer in complete sentences in the box to the right.

<u>**Engage**</u>

Section A: Tent Setup	
Using the space provided, create step-by-step instructions for how to build the tent.	
How similar are the instructions that you designed? Is there more than one way to set up the tent?	
What design features of the tent made it challenging to construct?	
Where did problem solving and critical thinking come into place during setup?	

Section B: Mystery Box Design Challenge			
Trial #1	**Box #1**	**Box #2**	**Box #3**
Predict: What do you think will happen if half of a beaker of water is poured into the box?			
Observe: In your own words, describe how much water went into the box, and how much water came out.			
Reflect: Why do you think happened in the box that resulted in the outcome observed?			
Planning Trial #2			
What will your team add to the mystery boxes to determine what the inside looks like?			
Trial #2	**Box #1**	**Box #2**	**Box #3**
Predict: What do you think will happen if half of a beaker of water is poured into the box?			
Observe: In your own words, describe how much water went into the box, and how much water came out.			
Reflect: Why do you think happened in the box that resulted in the outcome observed?			

Planning Trial #3			
What will your team add to the mystery boxes to determine what the inside looks like?			
Trial #3	**Box #1**	**Box #2**	**Box #3**
Predict: What do you think will happen if half of a beaker of water is poured into the box?			
Observe: In your own words, describe how much water went into the box, and how much water came out.			
Reflect: Why do you think happened in the box that resulted in the outcome observed?			

Section C: Sailors and Coconuts
Use the space provided to answer the Sailors and Coconuts problem. Be sure to show your reasoning, as you will be sharing your method of solving the problem with the class.

What problem solving and critical thinking strategies did you use to solve this problem?	

Explore:

Section D: Crossing the River	
What was the initial strategy your team used to cross the river?	
What challenges did you and your team come across? How did you adapt to overcome these challenges?	
Who or what helped to make this river crossing possible? Why was that important?	
How could you use these problem solving skills in everyday life?	
Section E: The Problem with Fab Downtime	
After reading the article, answer the following questions regarding semiconductor fabrication equipment failures.	
Identify the problem the article has identified with downtime in the fab industry.	
What are some potential solutions to this problem?	

Explain:

Section F: Types of Problems in the Semiconductor Industry	
Read the article about common issues with semiconductor manufacturing equipment, then answer the following questions.	
Dicing Machinery	
How is improved productivity achieved?	
How is improved equipment accuracy achieved?	
How are components prevented from loosening during vibrations?	
Die Bonder	
How is high-speed bonding achieved?	
How are components prevented from loosening during vibrations?	
Wire Bonder	
How is high-speed bonding achieved?	
How are components prevented from loosening during vibrations?	
Mounting Machinery	
How is high-speed bonding achieved?	

Section G: Troubleshooting Steps	
Watch the video about the Semiconductor manufacturing troubleshooting process, and answer the following questions.	
Why are there so many steps needed before a problem can be diagnosed?	
Why is it important to quickly respond to any problems that occur in a manufacturing facility?	

Elaborate:

Section H: Troubleshooting Toolkit Case Study	
Read the Case Study, and answer the following questions. Be prepared to discuss with the class.	
What was the problem identified in the case study?	
What was the process taken to determine a solution?	
What was the result of the process taken?	
Why is troubleshooting an important part of the semiconductor manufacturing process?	
Section I: Quandary	
Once you have completed playing the game Quandary, answer the following reflection questions.	
What if there was another colony on Planet Braxos with a different Captain? How would this impact your decisions?	

Why do you think it's important to understand other points of views?	
Describe a similar problem you have had in your own life – a problem where there's no clear answer and you didn't know what to do?	
What have you learned from the game that would help you make decisions when you face similar problems in your own life?	
How might this decision-making practice help your problem-solving skills in the semiconductor industry?	