Exploring Engineering with

The Tech Challenge

Go Rover Go

Multi-session Design Challenge

Learner Objectives

Learners will:

- use the innovative design process.
- develop skills in written communication as they begin an engineering journal.
- design and prototype a device that uses wheels and axles to roll to a target area.
- present their solutions; give and receive feedback.

Table of Contents

This multi-session resource provides four scaffolded sessions and tools for building problem-solving skills in STEM while preparing students for The Tech Challenge. These lessons emphasize process over product, focusing on brainstorming, prototyping, and sharing solutions.

Explore Design Challenge Learning

Find this icon next to educator tips for teaching design challenges. Go to The Tech Interactive's **Explore Design Challenge Learning** website (thetech.org/explore-dcl) to see these short Tech Tip videos and PDFs.

We need your help ...

This resource is a prototype developed by The Tech Interactive to support educators and students new to Design Challenge Learning and The Tech Challenge.

We are always iterating and improving too, so don't hesitate to reach out to our team with any questions or feedback as you use this resource. We look forward to hearing from you! education@thetech.org

Planning Schedule

	Session 1 Innovation Design Process	Session 2 Brainstorming	Session 3 Engineering Journals	Session 4 Share Solutions
	60 min total	**60 min total**	**60 min total**	**60 min total**
Welcome	What is engineering?	What is brainstorming?	Why do people use journals?	Why do we share solutions and give feedback?
Activity 1	Design Challenge: Build a Rover	Material Investigation Brainstorm	• Engineering Journal • The Journal: Who, What, When, Why?	Feedback: Norms for Constructive Feedback
Activity 2	Introduce Innovation Design Process	Rover (Prototype 2)	Rover (Prototype 3)	Rover Team Share-out
Closing	Reflect on Session 1	Reflect on Brainstorming	Reflect on Session 3	Reflect on Rover Challenge
Cleanup	Clean up and Save Devices			Clean up and Recycle Devices
	see pages 4-10	see pages 11-16	see pages 17-23	see pages 24-27

Notes and Tips

- Each session is 60 minutes. Timing of the sessions can be adjusted to meet the needs of your program.
- Use the first session to set a positive tone for the rest of the sessions.

See the **Appendix** on page 28 for Vocabulary, Standards, and Student Handouts.

Innovation Design Process

During the first session, you will talk about the Innovation Design Process with students.

- Watch the Design Challenge Learning Video and review the Tech Tip PDF at (thetech.org/explore-dcl).
- *Optional:* Print the **Innovation Design Process Poster** to show learners during the lesson.

These are both designed for educators, but you may find parts of them useful to share with learners as well.

Agenda

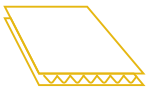
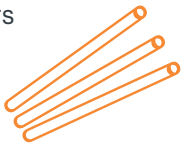
10 min	**Welcome: What is Engineering?**
30 min	**Activity 1: Design Challenge—Build a Rover**
10 min	**Activity 2: Introduce Innovation Design Process**
5 min	**Session Close: Reflect on Session 1**
5 min	**Cleanup**

Materials and Prep

Materials

Look for items that match the categories in the **Suggested Building Materials** below.

- Try to provide several different types of items for each category. Don't limit yourself to the items on this list. Use whatever you have on hand. Be creative!
- Materials can vary among groups and do not need to be identical.

Suggested Building Materials			
2–4 items per team			10–15 items per team
Round objects	**Structural pieces**	**Flexible objects**	**Fasteners**
□ Bottle caps (plastic) □ Cardboard tubes □ Plastic cups □ Plastic lids □ Ribon or thread spools □ Straws 	□ Cardboard  □ Chopsticks □ Dowel rods □ Empty food containers □ Ice cream sticks □ Rulers 	□ Balloons □ Coffee filters □ Metal springs □ Plastic bottles □ Rubber bands (multiple sizes) 	□ Binder clips □ Chenille stems (pipe cleaners) □ Magnets □ Paper clips  □ Plastic clips □ Rubber bands (multiple sizes) □ String  

Also need: Cardboard boxes, bags, or small bins to organize and store materials. 

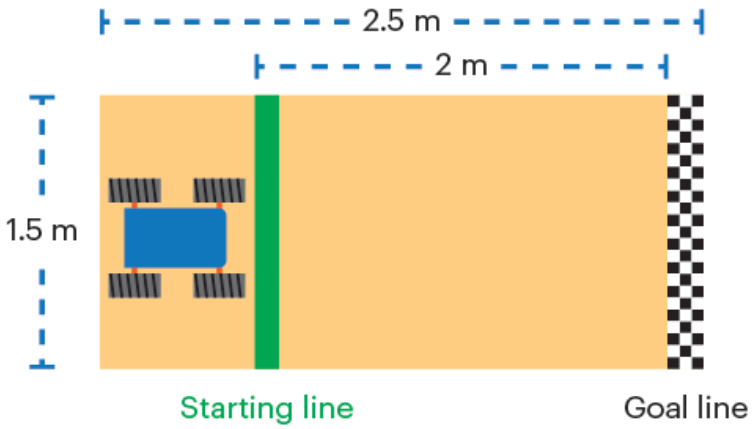
Have a plan for labeling and storing team devices throughout this design challenge. Students can cleanup, take apart, and sort supplies for reuse.

Tip: Don't use glue and limit the use of tape. This allows for faster iteration, more reuse of materials, and less mess.

1 set per team	Per class
Tools	**Test area supplies**
□ Hole punch □ Scissors 	□ Tape (i.e.: gaffers, blue, masking, etc.) □ Small object that devices must carry (cork, bottle cap, etc.)

Test Area Set-up

1. Designate a testing area in your classroom that is at least 1.5 meters wide and 2.5 meters long.
   - ***Note:*** If you don't have enough room in your classroom, you could run the design challenge outside, in a hallway, or in a multipurpose room.
2. From the short end of the space, tape a start line to the floor.
   - Make sure there is space behind the starting line for teams to line up for testing.
3. Measure 2 meters from the tape line to the long end of the space. Tape a finish line to the floor.



Preparation

1. Do the design challenge yourself. This will give you practice with the materials and tools to be able to anticipate learner questions.
2. Organize and set up materials.
   - If desired, create "kits" or sets of materials to pass out to each group to start with.
     - Another option is to arrange materials by category for groups to browse "buffet" style.
   - Use small bins to organize and store materials.
   - Decide where you will store projects between sessions.
     - Students can cleanup, take apart, and sort supplies for reuse.
3. Decide how learners will form teams for this design challenge. They will need to work in the same group of three or four for the entire four-session design challenge.
4. Make sure you have audio/video set up if you plan to share any videos with learners.

First Meeting

Each session begins with a **Welcome** which introduces the day's activities.

- For the first meeting, it can be helpful to start by setting group agreements, or guidelines that set expectations. Having learners help develop them can get the design challenge off on the right start.
- Follow up with an ice breaker, or a brief activity designed to help members of a group to begin working together. Icebreakers can also be done at the beginning of other sessions to introduce a topic or build collaboration and energy.

(See below for recommended examples of agreements and icebreakers for the first session.)

Session Directions

Welcome: What is engineering? *(10 min)*

1. If this is the first time these learners have worked together, do a quick icebreaker and set group agreements.

Ice Breakers Examples

- **Same and Different:** Challenge groups to think of one thing they all have in common and one thing that is different for each of them. (E.g. We're all 12 years old, but we have different numbers of brothers and sisters.)
- **Name Game:** Have each learner share their name and something they like that starts with the same letter (or rhymes). All the other students in the group repeat what they say. (E.g. My name is John and I like jam.)

Sample Group Agreements:

- **Dive in!** Be bold!
- **Be curious!** Ask why? How? What if? Consider new perspectives.
- **Make mistakes!** Learn and persevere.
- **Play!** Tinker, create, and have fun!

2. Introduce learners to what they will be doing over the next four sessions.

Sample Introduction:
Starting today, you are all engineers! You will be building and designing solutions to a variety of real-world problems. We'll work in teams, challenge ourselves, and most of all, we'll have fun!

3. Ask one of the **Guiding Questions.**

Guiding Questions

- *Have you built or designed anything before?*
- *What kinds of things do you like to make and create?*

4. Emphasize that creativity comes in different forms and can be found in any career.
   - Connect this to creative problem-solving and the ways in which engineers solve problems.
   - As you explain, make connections with the example learners shared of things they have built and created.
5. Explain what engineers and engineering are and what they do. Have learners share ideas of problems an engineer might work on.
   - Guide them to think of new ideas, beyond the most obvious bridges, vehicles, or electronics.

Sample Explanations

Engineers:
An engineer is a person who designs and builds complex products, machines, systems, or structures to solve a problem or meet a need. Engineers want to know how and why things work. Engineers are changing the world all the time. They think up creative solutions and work with other people to invent, design, and create solutions to real-world problems.

Engineering:
Engineering is the process that engineers go through to imagine, create, build, and test a solution.

Engineering careers:
- *Mechanical engineer, civil engineer, software engineer, chemical engineer*

Problems they solve:
- *Software design, city planning, new medications or medical devices, new materials or systems*

Activity 1: Design Challenge—Build a Rover

Note to Facilitator

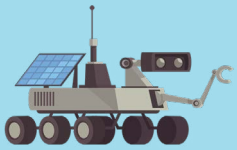
Your goal for this activity is to introduce learners to the Rover Design Challenge and the Innovation Design Process. They will also have some time to begin prototyping and share their initial ideas.

- During this session, learners will have a chance to experience rapid prototyping and see how they can learn from early testing and sharing solutions.
- Learners will have four sessions to work on the Rover Design Challenge, so don't spend extra time on any one section. Let learners know that the best way to understand what they will be doing in the program is to try it.

Frame the Challenge *(5 min)*

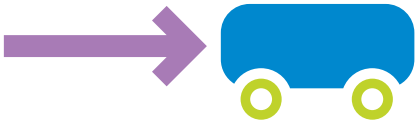
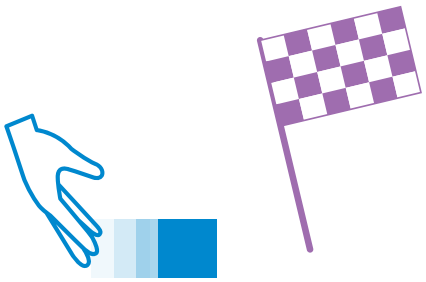
1. Introduce the Rover Design Challenge with a design scenario.

2. Use an engaging story related to the challenge that you think your learners will find interesting, motivating, and relevant.



Sample Design Scenario:
Your engineering team is working with the International Space Agency to develop an exploration rover that can travel across a dwarf planet found in our solar system. The first thing your team needs to do is to design a prototype rover that can move by rolling.

3. Introduce the design problem, criteria, and constraints.

Design Problem	Design a device that rolls to reach the target area.	
Criteria (How you know it's successful. What to "test" for.)	• Device needs to roll in a straight line from the starting line to past the finish line. • Device may be pushed gently to start motion. • Device must safely carry an object past the finish line.	
Constraints (Limitations)	• Use only the materials provided. • Build within the time limit.	

4. Show learners the test area.
   - Explain testing by showing them the line their device needs to start from and the finish line.
   - Let them know that a person on their team can push the design to start it.

Prototype *(15 min)*

1. Tell teams that it is time to prototype. Let them know that during this time they can imagine, create, test, and reflect on their designs.
2. Provide access to materials and have learners begin building.
3. During the prototyping time, walk around and support the teams.
4. Ask facilitative open-ended questions to guide their process.
5. Give them reminders about the time and let them know that when they finish they will share their ideas even if they haven't completed them.
6. Encourage them to test multiple times and collaborate with each other and other teams.

Prototype Questions

- *What do you notice about the materials? How can you use or combine them differently?*
- *What are you still trying to understand or imagine?*
- *Which parts of the device can you test as you build?*
- *What else could you try?*

Share Solutions *(10 min)*

1. At the end of the time limit, learners stop even if they haven't been able to build or complete something.
2. Model sharing with the whole group. Ask a team who has a partially built device to model with you (This will help learners to focus on process rather than product).
3. Pair up teams and have them take turns sharing their devices with each other. Use the sharing questions to guide the sharing.
4. After each team shares, have the learners in the other group give positive feedback on the designs. Encourage them to tell the other team one thing they liked or thought worked well.
5. Walk around to hear what teams are sharing and note some of the things you heard at the end of the sharing.
6. If time remains, have teams rotate to share with another group.
   - To facilitate this process, play music, which tells learners when to stop and share and when to move on to share with a different group.

Sharing Questions

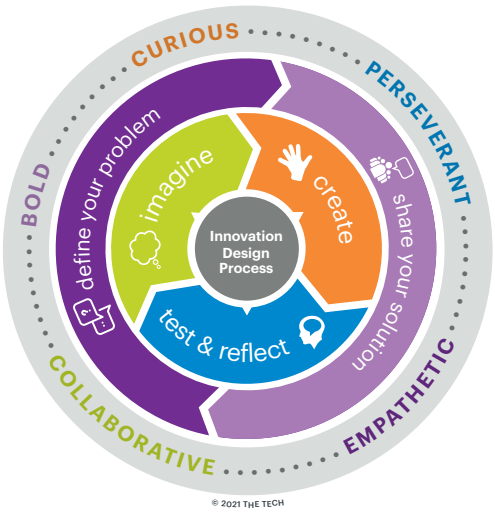
- *Tell us about your design and how it worked.*
- *What changes did you make as you were building?*
- *What did you notice when you tested?*
- *What changes would you make if you had more time?*

Activity 2: Introduce the Innovation Design Process *(10 min)*

1. Tell learners that what they just experienced was a design challenge. Have them reflect on the experience.
2. Then, introduce the Innovation Design Process and share the poster.
   - Reminder: See thetech.org/explore-dcl for these resources.
3. Point out the different parts of the process: define your problem, imagine, create, test and reflect, and share solutions.
   - Explain that it is nonlinear and iterative. They might start at any place, and they will repeat many parts of it as they create solutions.
4. Have them think about times and examples of where they used the different aspects.
   - ***Example:*** Where did you notice yourself imagining solutions during the design challenge? Learners may mention that in addition to the beginning of the process, some of them got new ideas when other groups were sharing solutions or by looking at materials.
   - Remember, the goal of introducing the process is not for learners to memorize it, but instead create a shared vocabulary and understanding of the process.

Reflection Questions

- *What did you notice about the experience?*
- *What did you like about it?*
- *What was challenging?*



Session Close

Reflect on Session 1 *(5 min)*

1. Use the Strategy and Sample Reflection Questions below to reflect on the design process.
   - Make sure everyone has a chance to participate and think about what they learned.

Focus: Reflect on Session 1

Strategy:

- **Closing Circle:** Have everyone stand up and take turns sharing. Responses can be one word or just a short phrase.

Reflection Questions

- *What did you learn today? What would you like to try next?*
- *Any shout-outs to team members?*

Cleanup *(5 min)*

1. If learners have not already done so, lead them in a cleanup of materials.
   - Always remind learners to separate out what can be reused and recycled.
   - Have learners/teams write their names on anything they made and place it in the designated area for use in the next session.
2. Play music and say that everything must be cleaned up by the time the song is finished.
3. If possible to do so safely, leave the test area set up for the next session.

Notes

Agenda

5 min	**Welcome: What is Brainstorming?**
15 min	**Activity 1: Material Investigation Brainstorm**
30 min	**Activity 2: Rover (Prototype 2)**
5 min	**Session Close: Reflect on Brainstorming**
5 min	**Cleanup**

Materials and Prep

Materials

- ☐ Rover Challenge Materials and Prep (Same as Session 1)
- ☐ **Material Investigation Handouts (See Appendix)**
- ☐ **Go Rover Go Challenge Cards (See Appendix)**
- ☐ **Data Collection Handout (See Appendix)**
- ☐ Team devices
- ☐ Writing utensils or markers (1 per learner)
- ☐ Sticky notes

Preparation

1. Print the **Material Investigation** and **Data Collection Handouts** (see Appendix) (1 set per team).
2. Set up the materials and Test Area as in Session 1.
3. Have the **Go Rover Go Challenge Cards** (see Appendix) ready to share with learners. This can be printed, but can also be shared on the board, on chart paper, etc.
4. Make sure each team has their devices from the previous session.

Notes

Educator Tech Tip: Brainstorming

This lesson introduces formal brainstorming techniques that demonstrate how imagining solutions can be closely connected to building and prototyping.

- Some learners find it useful to physically examine the materials and Test Area while brainstorming.
- To reinforce the connection between imagining and building, this session is scheduled so that learners will have a chance to build and prototype their ideas right away.

See the Brainstorming Tech Tip and video at (**thetech.org/explore-dcl)** for more information and tips on brainstorming. These are both designed for educators.

Session Directions

Welcome: What is brainstorming? *(5 min)*

1. Let students know that today they are going to be exploring how they come up with new and interesting ideas.
2. Ask one of the **Guiding Questions**.
3. Invite learner responses and lead a short discussion about the purpose of brainstorming and some of the different techniques they may have used to brainstorm in the past.
4. Let learners know that they will be given new criteria in this session. They will need to add a wheel and axle to their design.
5. Explain to the learners that today they are going to be trying a kind of brainstorming called a material investigation: a deep exploration of the materials to consider the possible ways they could use them to make their designs more reliable.

Guiding Questions

- *How do you come up with new ideas?*
- *What is brainstorming?*

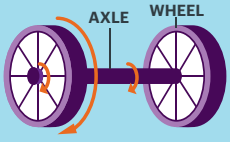
Learners may share some of the following ideas:

- Brainstorming often sets a formal structure for the "Imagine" section of the Innovation Design Process.
- The goal of brainstorming is to generate a lot of ideas, so all ideas are welcome. No judgment!
- Brainstorming can be done with a group or individually.

Activity 1: Material Investigation Brainstorm

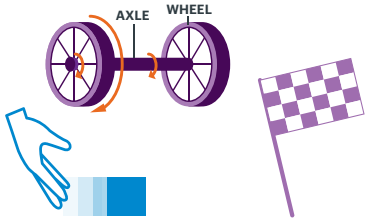
Introduce New Criteria *(5 min)*

1. Introduce teams to the next stage of the design scenario:



Sample Design Scenario:
Your engineering team is working with the International Space Agency to develop an exploration rover that can travel across a dwarf planet found in our solar system. The first thing your team needs to do is to design a prototype rover that can move by rolling. **After examining the terrain, the team has decided that they need to use a wheel and axle in the design.**

2. Review the new criteria and address any questions that students have.

Design Problem	Design a device that rolls to reach the target area.	
Criteria (How you know it's successful. What to "test" for.)	• Device needs to roll in a straight line from the starting line to past the finish line. • Device may be pushed gently to start motion. • Device must safely carry an object past the finish line. • **New Criteria:** Device must include a wheel and axle.	
Constraints (Limitations)	• Use only the materials provided. • Build within the time limit.	

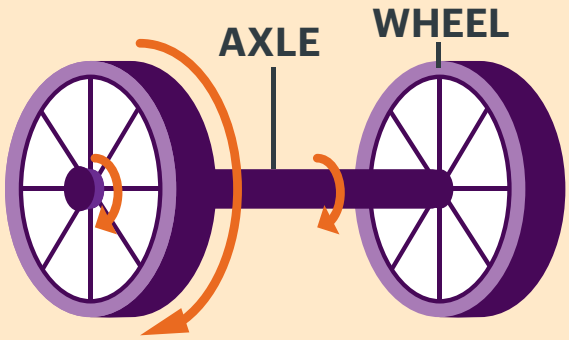
Material Investigation Brainstorm *(10 min)*

1. Let learners know that they will now have some time to brainstorm ways they could incorporate a wheel and axle into their design.
   - Establish expectations (if you haven't done so already) around sharing ideas, supporting each other, and creating a non-judgmental environment.
   - This is a time to encourage wild ideas, reframing prior knowledge and connections, and building team relationships. Encourage teams to record every idea.
   - Remind them to strive for quantity over quality, brainstorming as many creative ideas as possible.
2. Pass out the Material Investigation Handout. Ask them to spend this time playing with the materials to learn more about their physical components, properties, or characteristics, then record their findings on the Material Investigation Handout.
3. Have teams collect materials. While teams are exploring the materials, encourage them to be curious about which properties may be most effective for solving this problem.
   - What kinds of materials could potentially act as wheels?
   - What could you use to allow the axle to spin freely? What kind of texture should that material have?
4. When they are ready, have the teams call you over and share what they recorded about the materials and why they think they will work well as the wheel and axle.
   - As teams share, point out that there are no correct answers and there are multiple ways to develop reliable prototypes.

Wheels and Axles

Rolling vehicles are most familiar to learners, but designing wheel systems can be challenging.

- Encourage students to think of things that have wheels such as cars, carts, trains, bikes, etc.



Ask questions to help learners share what they already know about wheels:

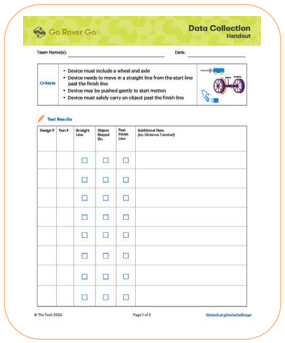
- *What kinds of jobs are easier with wheels?*
  - *How does a wheel turn?*
- *How is a bicycle wheel connected to the motion of the pedals?*

Learners may try creating an axle by connecting two round items to a long structural item at either end.

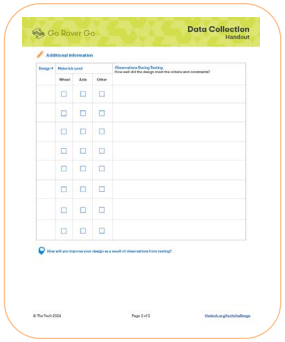
- They will find that the axle will need to be attached in such a way that it rotates freely, allowing the wheels to turn.
- ***Example:*** Putting a chopstick inside a large boba straw.

Activity 2: Rover (Prototype 2) *(30 min)*

1. Pass out the **Data Collection Handout.** Teams can use this tool to track the reliability of their devices.
   - Review the testing process and criteria with students.
2. Then have teams get out their devices and start prototyping. Remind them that their goal is to apply what they learned about materials to their device.
3. Walk around and support teams as needed.
4. Ask facilitative, open-ended questions to refocus the teams on the process rather than product. Motivate them to feel successful even when a whole device or idea doesn't work in that particular moment.
5. Encourage learners to test often and collaborate with each other.
6. If teams feel like they are "done," ask them what else they can do to improve their design.



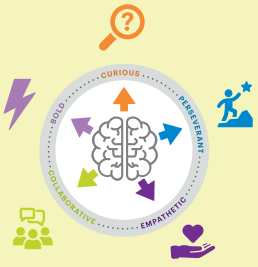
Data Collection Handout Page 1



Data Collection Handout Page 2

Educator Tech Tip: Innovator Mindsets

See The Tech Interactive's Innovator Mindsets Tech Tip and Video at (thetech.org/explore-dcl) for more guidance on incorporating practices and reflection around perseverance, boldness, curiosity, empathy, and collaboration into design challenges.



Prototype Questions

Starting to Build

- *Were there other materials that you investigated that you could use on your device?*
- *How can you make sure the device travels in a straight line?*
- *Are there ways to make sure it will work reliably?*

After Testing

- *Was the device able to travel in a straight line with the addition of the wheel and axle?*
- *Was the device able to keep the object safe?*
- *Did you notice anything else about the way your device traveled?*

Problem Solving

- *What components are working in your team's design?*
- *What caused the design to fail during testing? How can your team start to alter that part of the design?*
- *Which parts of the device can your team test to inform the overall design?*

Pushing Design Further

- *What can your team try to make this design even better?*
- *What is a different way to solve the problem?*

- Encourage them to test multiple ideas during this time rather than deciding on a final model.
- Prototyping is a great way for them to begin to narrow down some of their brainstorming ideas.

7. If teams still feel that they have completed the design challenge with time left, show them the **Go Rover Go Challenge Cards (see Appendix).**
   - Ask them to choose one to use as a new criteria.
   - Have them try to complete this new criteria as they improve their device.

Go Rover Go Challenge Cards

Remind yourself and your learners to celebrate early and often.

There are plenty of milestones to celebrate if you break things up in steps. Celebrating can be as simple as getting excited that a small part of a prototype is working.

Session Close: Reflect on Brainstorming *(5 min)*

1. Use the Strategy and Sample Reflection Questions below to reflect on brainstorming.
   - Make sure everyone has a chance to participate and think about what they learned.

Focus: Brainstorming

Strategy:

- **Closing Circle:** Have all of the learners form a circle. Encourage each person to share an idea of something they learned from brainstorming.
  - One option to facilitate this is to toss a ball of yarn around the circle and have learners form a web. This can represent how their ideas are all connected and inspire and motivate each other.

Reflection Questions

- *What did you learn from the brainstorming process?*
- *What was most surprising about your brainstorming session today?*

Cleanup *(5 min)*

1. If learners have not already done so, lead them in a cleanup of materials.
   - Have learners/teams write their names on anything they made and place it in the designated area for use in the next session.
   - Always remind learners to separate out what can be reused and recycled.
2. If possible to do so safely, leave the test area set up for the next session.

Notes

Agenda

5 min	**Welcome: Why do people use journals?**
20 min	**Activity 1: Engineering Journal**
10 min	**The Journal: Who, What, When, Why?**
15 min	**Activity 2: Rover (Prototype 3)**
5 min	**Session Close: Reflect on Session 3**
5 min	**Cleanup**

Materials and Prep

Materials for Challenge

□ Rover Challenge Materials and Prep (Same as Session 1)

Materials for Journal Activity

□ Pencil/Pen (1 per learner)

□ Team Engineering or Tech Challenge Journals (1 per team)

□ 8.5 x 11 in paper for paper airplanes

- ***Note:*** Choose the format for the journal that works best for your situation: notebook, binder, recycled paper assembled by learners, or online document/tool.
- If students are participating in The Tech Challenge, they will need to submit their journal in the form of a PDF for the Showcase.

Preparation

1. Set up the materials and Test Area for the Go Rover Go Challenge as in Session 1.
2. Prepare for the journal activity:
   - Build your example of a complex paper airplane.
     - If you need instructions on how to create a complex paper airplane, try recreating a medium or hard level paper airplane from Fold 'N Fly.
   - Hide it in a box or behind a barrier. Placing it on an upside-down bankers box lid and covering it with the upside-down box also works well.
     - ***Note:*** You will need to have space around it for learners to view it in small groups when it is revealed at the end of the activity. Make sure the device is stable enough to move.
   - Distribute paper for each group.
   - Set aside the paper and pencils, as they will be introduced halfway through the journal activity.
3. If you plan to use roles with teams, this is a good session to introduce them to learners. Consider which roles you will use — for example, timekeeper, materials manager, scribe, etc.
   - Remind them that even though they have a role, they should participate in all aspects of the design process.

Session Directions

Welcome: Why do people use journals? *(5 min)*

1. Set the stage for the lesson and let learners know what the focus is for the session.
2. Ask one of the **Guiding Questions**.
3. Invite learner responses and lead a short discussion about the purpose of journals and some of the different techniques they may have used for them in the past.

Guiding Questions

- *Why do people use journals?*
- *What are some situations where people need to communicate information with others or themselves?*
- *What are engineering journals?*
- *How do engineering journals differ from personal journals?*

During the discussion, point out:

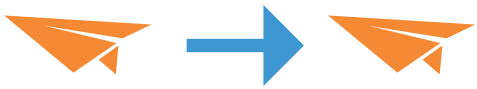
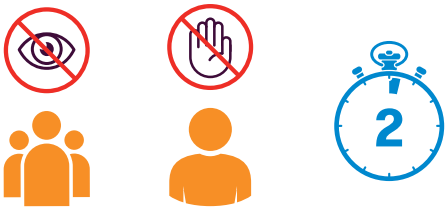
- Journals help us track and remember ideas.
- They provide a place for those who think by drawing and writing to put their ideas.
- They may be used by an individual to keep track of a project over time, or within a team to communicate complex information (***example***: Mars mission or new product launch).
- Engineers use journals in their work and practice:
  - To record ideas, inventions, experiments, observations, etc.
  - As a source for you and others to refer to in order to understand how something works, how to build it, and why specific decisions were made.
- An engineering journal is a "living" document that changes and grows throughout the design process.

Activity 1: Engineering Journal *(15 min)*

Introduce the Activity *(3 min)*

1. Tell learners they are going to play a quick game that considers how we communicate information.
2. Have learners get into teams of three or four. (These can be the same as the team working on the design challenge or a new group.) Tell them that you have created a device that they will need to re-create as a team.
   - However, they can only send one representative from their team to view the device.
   - The person who views the device cannot touch the materials.
   - The people building the device cannot see the device.

3. It may help to present these directions in the format of a design challenge (see example below).

Design Problem	Re-create the device exactly.	
Criteria	The device looks exactly the same.	
Constraints	• The people building cannot see the device. • One person from the team can view at a time. • The person who views the device cannot touch the materials. • There is a time limit of 2 minutes.	

4. Before giving students the materials, have them choose:
   - who builds
   - one person to view the sample device
5. Then tell them how they can see the device and make sure it is not visible to the learners that are building.

Build Time *(5 min)*

1. Once learners understand the instructions, have them start. Monitor the process and ensure that learners are following the constraints.
2. After about 5 minutes, have learners freeze.

Introduce Paper and Pencil *(5 min)*

1. Let learners know that they can now designate one person on the team who is allowed to write with paper and pencil.
   - Have this person come up and collect the paper and pencil.
   - ***Note:*** This individual is also allowed to go and look at the device.
2. Continue the game for 2–3 more minutes.
3. If a team thinks that they have recreated the device exactly, they should call you over to "test" it by checking how accurate it is.

Share Results and Debrief *(7 min)*

1. Call "time" and have learners stop building.
2. Reveal your device to the class and have teams hold up their results to compare. Acknowledge and celebrate the work of all the groups.
3. **Debrief** the activity with a couple questions.
4. Learners should be able to explain how writing and drawing their ideas helped them communicate. They should also notice that clear, detailed directions are important.
   - They may notice that data (number of items used) and measurements (even informal: "as wide as my hand") helped them re-create more accurately.

Debrief Questions

- *What techniques worked for your team? What helped you communicate?*
- *What was challenging about this activity? What made it difficult to communicate?*

The Journal: Who, What, When, Why? *(10 min)*

1. Let learners know that each time they work on a design challenge, they will keep notes in their team's engineering journal.
   - First make sure they understand ***why*** keeping a journal is useful.
   - Refer to the activity as well as the Go Rover Go design challenge and how a journal might have been useful.
2. Ask: *Why is keeping an engineering journal useful?*

During the discussion, point out:

- Journals help us track and remember ideas.
  - *There might be an idea from the first Session of building that helps you on Session 4, or even Session 18 of a different challenge!*
- Journals show how ideas have changed and decisions were made.
  - *They help teams work together; when someone is absent they can check the journal to see what they missed.*
- When testing your ideas you'll need a place to record detailed measurements and data.
  - ***Example:*** *Oh, it went 5 inches farther that time!*
  - ***Example:*** *When we used cardboard it was faster.*
- They are a great place for doodling, brainstorming, and sketching.
  - *Engineers use journals to record detailed schematics, document the engineering process, iterate, and redesign.*

3. Next, discuss what will go in the journal and how and when learners will use their journals.
4. Together, make a list of the types of things they will take notes on in the different journals.

Ask: ***What kinds of things do you think we should record in the journal?***

Student ideas may include:

Team Engineering Journal

- Brainstorms and ideas
- Sketches and drawings of devices
- Notes about what they did in that Session
- Test results
- Data and measurements
- Notes about what worked and what did not
- What they want to try next
- What they are proud of
- Questions they have; difficulties they are working through

5. Highlight the following during the discussion, using examples where possible:
   - Journals should include notes, not an essay.
   - They should have a combination of drawings, notes, sketches, and testing results related to the device.
   - Each journal entry should include important labels and organizing ideas (date, what they were doing, what that part of the device is).
6. Remind them that **Team Engineering Journals** are a collaborative tool and should be used by the entire group to track and show their progress.
   - Therefore, each team member should help contribute and take notes even when there is a designated note taker.

Journaling Video Option

"Tech Tools: Journaling" *(4 min)* uploaded by The Tech Interactive to YouTube in 2020.

Share this video with your learners to provide some examples of learner engineering journals and tips for creating them. It also shows design challenges in action.

Activity 2: Rover (Prototype 3) *(15 min)*

1. Before continuing prototyping, let learners know that they will be receiving informal feedback on their devices during the coming session. They should try to have a draft device done by the end of this session even if it is not fully functional.
2. During the prototyping time, walk around and support the teams.

3. Ask facilitative, open-ended **Prototype Questions** to guide their process.
4. Make sure teams test their devices several times during this session.
5. Encourage them to collaborate with each other.
6. Make sure teams are using their **Team Engineering Journals** and recording ideas.
   - Teams can continue to use the **Data Collection Handout** to capture their testing data in their journal.
   - Make sure they include the team name and the date.
   - ***Note:*** Additional details for this first journal entry can be very simple, just a sketch and a note on their progress.

Team Journals can include:

- What they are working on that day
  - Brainstorms and ideas
  - Sketches of devices they build (with labels)
- Test results
  - Data and measurements
  - Notes about what worked and what did not
- What they want to try next

Prototype Questions

Starting to Build

- *Tell us about your design.* ***How is your design supposed to work?***

After Testing

- *What did you notice about the way your device traveled?*
- *How can you make your device:*
  - *More stable?*
  - *Travel smoothly?*

Pushing Design Further

- *What can your team try to make this design even better?*
- *What is a different way to solve the problem?*

Problem Solving

- *What components are working in your team's design?*
- *Where are the failure point(s)? What caused the failure?*
  - *How can your team start to alter that part of the design?*
- *Which parts of the device can your team test to inform the overall design?*

Session Close: Reflect on Session 3 *(5 min)*

1. Use the Strategy and Sample Reflection Questions below to reflect on the session.
   - Make sure everyone has a chance to participate and think about what they learned.

Focus: General Session Reflection

Strategy:

- **Individual Reflection Quick-Write:** Have learners write responses to the questions on paper. Then add all of their thoughts to the Team Journal.

Sample Reflection Questions

- *What was challenging today?*
- *What inspired you today?*

Cleanup *(5 min)*

1. If learners have not already done so, lead them in a cleanup of materials.
   - Have learners/teams write their names on anything they made and place it in the designated area for use in the next session.
   - Always remind learners to separate out what can be reused and recycled.
   - Make sure you collect teams' journals as well and that they are clearly labeled with their names.
2. If possible to do so safely, leave the test area set up for the next session.

Notes

Agenda

5 min	**Welcome: Why do we share solutions and give feedback?**
15 min	**Activity 1: Norms for Constructive Feedback**
30 min	**Activity 2: Rover Team Share-out**
5 min	**Session Close: Reflect on Go Rover Go Challenge**
5 min	**Cleanup**

Materials and Prep

Materials

- □ Rover Challenge Materials and Prep (Same as Session 1)
- □ Team devices
- □ Team Engineering Journals
- □ Pencil/Pen (1 per learner)

Preparation

1. Write the schedule for the session where all teams can see it and understand when they will be sharing their devices.
2. Make sure teams have the materials and resources they will need to share their devices.

Educator Tech Tip: Sharing Solutions

Sharing is key to the design process and builds confidence in giving and receiving feedback. In addition to the sharing sessions throughout the design challenges, in the final session of Challenge 5, learners will have a chance to share their solutions with a larger audience.

- In this first Challenge, sharing is more informal.
- As learners become more confident, incorporate opportunities to engage in more formal sharing techniques in later Challenges.

See The Tech Interactive's Sharing Solutions Tech Tip and Video at (thetech.org/explore-dcl) for more guidance on creating a classroom culture that supports communication, constructive feedback, and iteration.

Session Directions

Welcome: Why do we share solutions and give feedback? *(5 min)*

1. Let learners know the focus for the session will be on sharing their solutions and giving each other feedback.
2. Ask the **Guiding Question**.
3. Invite learner responses and lead a short discussion about the purpose of feedback and some of the different techniques they may have used for this in the past.

Guiding Question

- *Why do we share solutions and give feedback?*

During the discussion, point out:

- *Having time to share and reflect is a critical part of learning.*
- *Sharing is a way to celebrate success; focus on the process not the product.*
- *Feedback is a critical part of the design process. Feedback provides data and new ideas with which to iterate and improve our designs.*
- *Sharing and feedback enable teams to incorporate, build upon, and give credit to innovations made by other teams.*

Activity 1: Norms for Constructive Feedback *(15 min)*

Team Check-in *(5 min)*

1. Let learners know that today they are going to demonstrate and share their devices with the rest of the class.
2. Remind teams that they do not need a functioning device in order to share. They will be sharing their process. The goal is to celebrate ***all*** of the teams and their process. Sometimes, "epic fails" are the most interesting and informative.
3. Give teams time to gather their devices, make sure they have their materials, and are prepared to share. This should include:
   - Doing a final test with their device.
   - Designating a spokesperson for their team or determining how they will split up the sharing time.
   - Planning what they want to say using the **Sharing Questions** as a guide.

Sharing Questions

- *How is your design supposed to work?*
- *What changes did you make as you were building?*
- *What does your design look like in action?*
- *What changes would you make if you had more time?*

Feedback Process *(10 min)*

1. Establish norms for giving constructive feedback by creating your own or choosing from/adjusting the suggestions here.
2. Have learners offer feedback in two categories, positive and constructive feedback.
   - ***Example:*** Wows and Wonders, Pluses and Deltas, Roses and Thorns, Strengths and Next Steps
3. Designate two or three people who will give feedback before a team shares, then take other volunteers (this allows everyone to participate).

Norms for Constructive Feedback

- Have the class establish their own norms and a few positive hand gestures (***example:*** "yes"= high five or "more of this"= bending pointer finger continuously up and down).
- "Yes, and," instead of, "Yes, but."
- Constructively critique the design (not team members).
- Celebrate all of the successes, even when small ("It moved 1 cm, yes!").
- Use "I" statements when contributing ideas and reflections.

Activity 2: Rover Team Share-out *(30 min)*

1. Each team will take turns sharing with the entire class. Manage the time so that all groups get to share.

   Tip: Choose a team to go first whose device did not perform as well in testing. Use this opportunity to set the tone for positive encouragement and a focus on the process rather than the end result.
2. Gather around the test area so each team can demonstrate their device as they share.
3. Once again, they should keep their sharing simple and focused on what they did and why. Give teams a time limit so each one can share.

Sharing Questions

- *Tell us about your design.*
- *What changes did you make as you were building?*
- *What did you notice when you tested?*
- *What changes would you make if you had more time?*

4. Facilitate positive feedback from the class after each sharing. Encourage a few teams or individuals to share one thing they liked and a suggestion for improvement after each team presents.
   - Again, use a class term for this feedback if it's helpful. (***Example:*** Wows and Wonders, Pluses and Deltas, etc.)

Tip: Take a photo of learners with their designs. Share the photo or video with your organization and The Tech Interactive, challenge@thetech.org and #TheTechChallenge.

Share Solutions for Go Rover Go Challenge 4

Session Close: Reflect on Rover Challenge *(5 min)*

1. First, have learners reflect **individually** on the Go Rover Go Challenge.

Focus: Individual Reflection

Strategy:

- Individual Journal Reflection quick-write.

Individual Reflection Questions

- *What is one thing you enjoyed about this design challenge? What is one thing you would change?*
- *What is one thing you are proud of in your work during this design challenge?*

2. Next, have them reflect on the design challenge as a **group**.

Focus: Class Reflection

Strategy: Choose one of these reflection strategies:

- Closing Circle
- Class Discussion

Class Reflection Questions

- *What have you learned?*
- *What is one thing you love and one thing you'd change about the class so far?*
- *Would you like to recognize someone today?* Use the sentence frame, *"I want to celebrate _____ for _____."* ***Example:***
  - "I want to celebrate the Blue Team for persisting through the tough problem with their spring mechanism."
  - "I want to celebrate Gabriela for trying new ways to work through frustration."
  - "I want to celebrate Andre for gaining confidence in sharing with the group."

Cleanup *(5 min)*

1. If learners have not already done so, lead them in a cleanup of materials.
2. As this is their last session for this design challenge, they can take apart their devices.
3. Materials used in this design challenge can be used again in the next one, so always remind learners to separate out what can be reused and recycled.

Vocabulary

- **Design scenario:** An engaging story related to the design challenge
- **Engineering:** The process of creating, designing, testing and building a solution
- **Prototype:** The models that engineers build to test as they develop their final solution
- **Wheel and axle:** A simple machine consisting of a wheel attached to a smaller axle so that these two parts rotate together

More Engineering Vocabulary

See The Tech Interactive's Language of Engineering Tech Tip at (thetech.org/explore-dcl) for more vocabulary and common engineering terms.

Next Generation Science Standards

Grade	Performance Expectation	Description
4	PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
5	ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
MS	ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
	ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
HS	PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy
Science and Engineering Practices		• Asking Questions and Defining Problems • Planning and Carrying Out Investigations
Cross Cutting Concepts		• Patterns • Cause and Effect

Student Handouts

Title	Number of Pages
• Material Investigation Handout	2 pages (double sided)
• Data Collection Handout	2 pages (double sided)
• Go Rover Go Challenge Cards	2 pages (double sided)

Material Investigation
Session 2 Handout

Team Name(s): _____ Date: _____

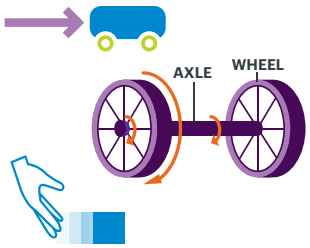
Material (ex: rubber band)	**Properties** (ex: flexible)	**How could this material be used in the rover?** (ex: stretch the rubber band around the wheel to connect it)

Space to Sketch

Inspired by the brainstorm? Add any drawings or diagrams of ideas for your wheel and axle designs below. Think about how you might use the materials together.

Data Collection
Session 3 Handout

Team Name(s): _____ Date: _____

Criteria	• Device must include a wheel and axle • Device may be pushed gently to start motion • Device needs to move in a straight line from the starting line past the finish line • Device must safely carry an object past the finish line	

Test Results

Design #	Test #	Straight Line	Object Stayed On	Past Finish Line	Additional Data (ex: Distance Traveled)
		☐	☐	☐	
		☐	☐	☐	
		☐	☐	☐	
		☐	☐	☐	
		☐	☐	☐	
		☐	☐	☐	
		☐	☐	☐	
		☐	☐	☐	

Additional Information

Design #	Materials used			Observations During Testing How well did the design meet the criteria and constraints?
	Wheel	Axle	Other	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	

How will you improve your design as a result of observations from testing?

Challenge Cards

Travel Farther

How far can you go?

Travel 2.5 meters total.

Slow and Steady

How fast can you go?

Cross the finish line within 3 seconds.

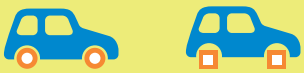
Heavy Load

How much can you carry?

Carry 3 objects past the finish line.

Dependable Design

Which change would improve your performance the most?

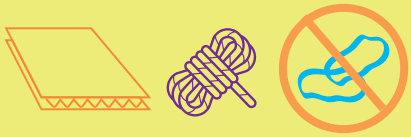


Change one part of your design and see how it performs.

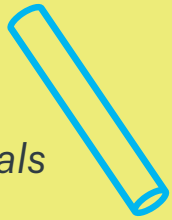
Materials Limit

What can you build with less materials?

Remove a material or try limiting the number you use.



Adjust the Materials



Which materials improve your performance the most?

For example, use only rigid or flexible materials.

Altered Terrain

How does your device perform on other surfaces?

Make the surface harder, softer or bumpy (***Example:*** add “moon rocks”).

Rapid Redesign

How quickly can your team work together to revise your design?

Set a timer for 5 minutes. Make sure you are all involved and collaborating.

Team Choice

What other criteria could you try?

As a team, choose a new way to improve your device and challenge your engineering skills.

Challenge Cards
(blank back)