Engineering Adventures℠

Go Green: Engineering Recycled Racers

Green Engineering for Out-of-School Time • Grades 3-5

Written by the Engineering is Elementary® Team
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EiE Engineering is Elementary®
Developed by the Museum of Science, Boston
Engineering Adventures

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Pilot Sites for Go Green

This unit would not be possible without the valuable feedback from our pilot sites!

- Arlington Elementary School, Lawrence, MA
- BCYF Leahy-Holloran Community Center, Dorchester, MA
- BELL and the Kenny School, Dorchester, MA
- Bielefield Elementary, Middletown, CT
- Boys & Girls Club of Cypress, Cypress, CA
- Boys & Girls Club of La Habra, La Habra, CA
- Boys & Girls Club of South Boston, Boston, MA
- Boys & Girls Club of Stanton, Stanton, CA
- Boys & Girls Club of the South Coast Area, San Clemente, CA
- Boys & Girls Club of Woburn, After the Bell 21st CCLC, Woburn, MA
- Boys and Girls Club of Greater Sacramento, Sacramento, CA
- Boys and Girls Club of Laguna Beach, Laguna Beach, CA
- Bridgepoint Academy, Miami, FL
- Brdige Street After School Program, Yuba City, CA
- Camp Fire Green Country, Tulsa, OK
- City of Healdsburg Parks and Recreation Afterschool Program, Healdsburg, CA
- Community Science and Technology Education Project, Philadelphia, PA
- Cummings 21st Century Afterschool and Kathy's Place Youth Center, Winthrop, MA
- Delaware City Schools, Delaware, OH
- East Boston YMCA, East Boston, MA
- Ferryway School, Malden, MA
- For Kids Only Afterschool, Everett, MA
- Foundations, Inc., Philadelphia, PA
- Gilsum MRSD Before and After School Program, Gilsum, NH
- Girl Scouts of Central Maryland, Nottingham, MD
- Girls, Inc. of Lynn, Lynn, MA
- GRASP, Boston, MA
- Heartland Foundation – empower U, Saint Joseph, MO
- High Desert Leapin Lizards, Ridgecrest, CA
- Honolulu Community Action Program, HI
- Imaginarium Science Center, Fort Myers, FL
- Italian Home for Children, Jamaica Plain, MA
- Jenny Lind School, Minneapolis, MD
- Killip Elementary School, Flagstaff, AZ
- Lynwood Unified School District, Lynwood, CA
- Malden YMCA, Malden, MA
- Martin Luther King Community School, Cambridge, MA
- Medford Boys and Girls Club, Medford, MA
- NYPENN Pathways Brownie Troop 50240, Potsdam, NY
- Partnership for Youth Development, New Orleans, LA
- Ridgepoint Elementary School, Ridgepoint, CA
- Sacramento Chinese Community Service Center (SCCSC), Sacramento, CA
- Salvation Army Children's Learning Center, Dorchester, MA
- Sitton SUN Community School, Portland, OR
- South Boston Catholic Academy, Boston, MA
- Tucker School, Milton, MA
- UCLA, CA
- US Synthetic, Orem, UT
- Williams Afterschool Club, Newton, MA
- Winter Hill Community School, Somerville, MA
- YWCA of Central Maine, Lewiston, ME
- YWCA of Hurley School, Boston, MA

Unit Map

Here is an overview of the adventures in this unit and how they all fit together.

Prep Adventure 1: What is Engineering?
Kids engineer a tower and are introduced to the Engineering Design Process as a problem-solving tool.

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Prep Adventure 2: What is Technology?
Kids explore the idea that they, as engineers, can design and *improve* technology.

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Adventure 1: Let's Get Rolling
Kids will build and test two wheel systems and see how well other wheel materials roll.

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Adventure 2: Scrap Market Engineering
Kids will think about how to use recycled materials as parts of toy cars and experiment with different wheel designs.

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Adventure 3: Recycled Racer Track
Kids will make the track that the Recycled Racer Rally will be held on.

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Adventure 4: Creating a Recycled Racer
Groups will use what they have learned from testing and from other groups to begin engineering their own racers.

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Adventure 4a Air Power (Optional):
Groups will be introduced to the idea that they can use air and sails to power their cars.

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Adventure 5: Improving a Recycled Racer
Groups will be able to perfect their racers and decorate them if they have additional time.

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Adventure 6: Engineering Showcase
Kids present the racers they engineered and share their knowledge of the Engineering Design Process.

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Introduction

Adventures

Note: The starred adventure represents an extension to the core curriculum.

About Engineering is Elementary

Engineering is Elementary® (EiE) fosters engineering and technological literacy among children. Most humans spend over 95% of their time interacting with technology. Pencils, chairs, water filters, toothbrushes, cell phones, and buildings are all technologies—solutions designed by engineers to fulfill human needs or wants. To understand the world we live in, it is vital that we foster engineering and technological literacy among all people, even young children! Fortunately, children are born engineers. They are fascinated with building, taking things apart, and how things work. Engineering is Elementary harnesses children's natural curiosity to promote the learning of engineering and technology concepts.

The EiE program has four primary goals:
Goal 1: Increase children's technological literacy.
Goal 2: Increase educators' abilities to teach engineering and technology.
Goal 3: Increase the number of schools and out-of-school time (OST) programs in the U.S. that include engineering.
Goal 4: Conduct research and assessment to further the first three goals and contribute knowledge about engineering teaching and learning.

The first product developed by the EiE program was the Engineering is Elementary curriculum series. Designed for use in elementary school classrooms, this curriculum is hands-on, research-based, standards-driven, and classroom-tested. For more information about EiE, visit: www.eie.org.

In 2011, EiE began development of Engineering Adventures (EA), a curriculum created for 3rd-5th grade children in OST environments. EA is designed to provide engaging and thought-provoking challenges appropriate for the OST setting. More information about EA can be found online at: www.engineeringadventures.org.

In 2012 the Engineering Everywhere (EE) curriculum was created. EE is designed to empower middle school-aged children in OST settings to become engineers and solve problems that are personally meaningful and globally relevant. For more information, visit: www.engineeringeverywhere.org.

Engineering is Elementary is a part of The National Center for Technological Literacy (NCTL) at the Museum of Science, Boston. The NCTL aims to enhance knowledge of technology and inspire the next generation of engineers, inventors, and innovators. Unique in recognizing that a 21st century curriculum must include today's human-made world, the NCTL's goal is to introduce engineering as early as elementary school and continue through high school, college, and beyond. For more information, visit: www.nctl.org.

About Engineering Adventures

The mission of Engineering Adventures (EA) is to create exciting out-of-school time activities and experiences that allow *all* 3rd-5th grade learners to act as engineers and engage in the engineering design process. Our goal is to positively impact children's attitudes about their abilities to engineer by providing materials uniquely appropriate for the varied landscapes of out-of-school time settings.

The main ideas that guide the developers of EA are listed below.

We believe kids will best learn engineering when they:
- engage in activities that are fun, exciting, and connect to the world in which they live.
- choose their path through open-ended challenges that have multiple solutions.
- have the opportunity to succeed in engineering challenges.
- communicate and collaborate in innovative, active, problem solving.

Through EA units, kids will learn that:
- they can use the Engineering Design Process to help solve problems.
- engineers design technologies to help people and solve problems.
- they have talent and potential for designing and improving technologies.
- they, too, are engineers.

As kids work through their engineering design challenges, they will have the opportunity to build problem solving, teamwork, communication, and creative thinking skills. Most importantly, this curriculum is designed to provide a fun learning opportunity for kids!

For more information on Engineering Adventures, please visit:
www.engineeringadventures.org.

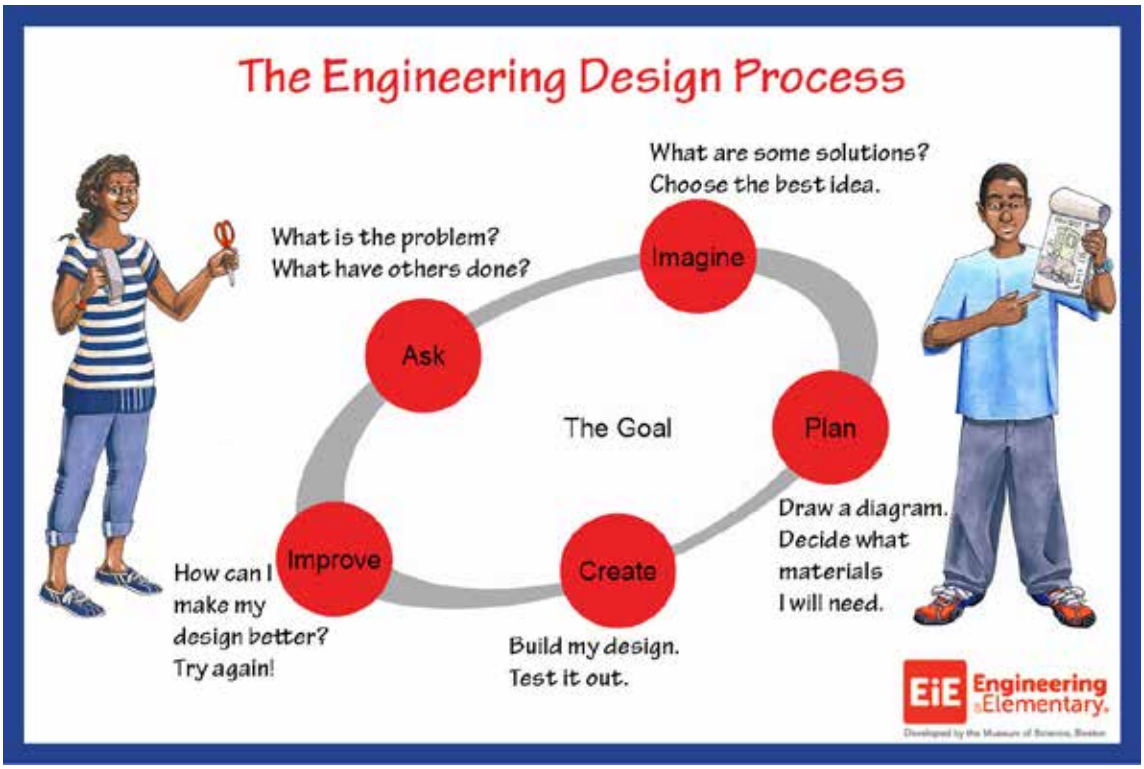
The Engineering Design Process

The Engineering Design Process (EDP) is the backbone of each Engineering Adventures (EA) unit. It is a five step process that guides kids in solving engineering challenges. Our goal for each EA unit is for kids to understand the EDP can not only help them solve problems in engineering but also in other areas of their lives.

While there are many other versions of the EDP that are used in academic and professional settings, the EiE team developed a five step process that is accessible for elementary school kids. India and Jacob, a fictional world-traveling brother and sister duo, introduce and guide kids through the Engineering Design Process in each unit. There are also questions for the educator to ask and sections in the Engineering Journal to provide an opportunity for kids to reflect on and discuss the process.

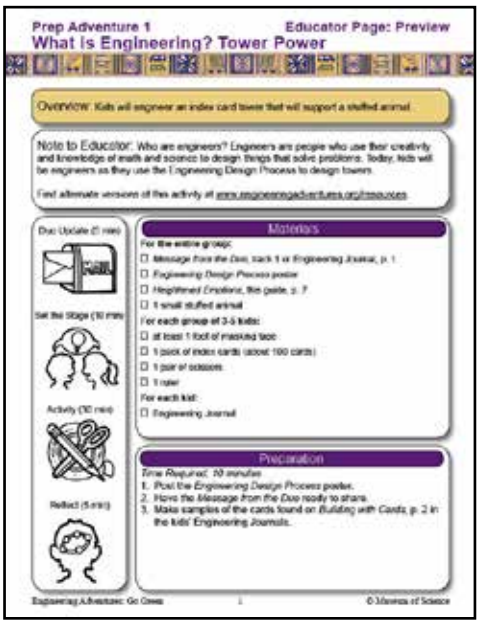
The EDP begins with the goal; the engineering challenge kids are asked to solve. The process is cyclical and flexible, kids can start a challenge at any step and may jump around to steps as they are engineering. For example, it is very common for kids to be creating their technology, but then ask questions about materials and imagine new ways to improve their design. In EA units, kids generally start with the *ask* step, then have time to *imagine* and *plan* their designs, then *create* and *improve* their technologies.

To further highlight the EDP throughout the unit, the steps are italicized in the guide. Below is the Engineering Design Process used in the Engineering Adventures units.

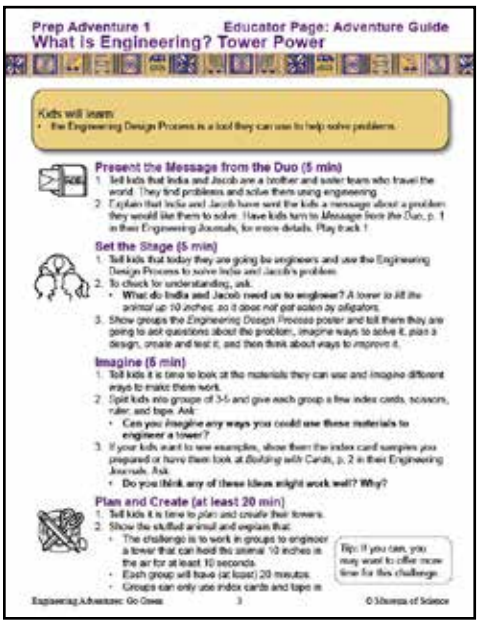


Each Engineering Adventure Includes

Preview pages with relevant background information, materials list, preparation instructions, and a preview of the journal pages needed.

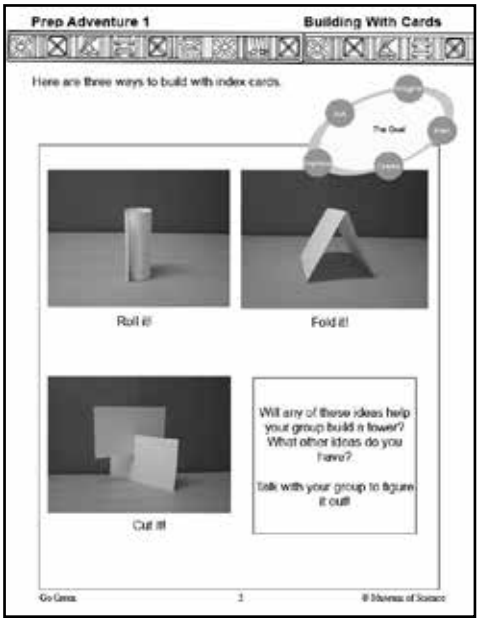


An **Adventure Guide** with step-by-step instructions, including discussion questions, extension ideas, and tips.



A **Message from the Duo**, India and Jacob, with information about the day's adventure.

Engineering Journal pages that allow kids to record findings and reflect on their learning.



The Sections of the Adventures

Messages from the Duo

Messages from India and Jacob, a fictional world-traveling brother and sister duo, are provided as a quick, exciting way to present the real-world context for the unit's engineering challenge. Providing a context helps kids to understand the challenge and motivates them to find solutions. If you have access to a CD, MP3 player, or iOS device, we strongly suggest using the audio recordings, although reading the emails aloud will convey the same information.

Set the Stage (Ask)

The Set the Stage, or Ask, part of each adventure provides important information and questions that prepare kids for the main activity. During this section, you might ask questions prompting kids to share their prior knowledge, have them predict what they will find, or remind them of criteria that will help them as they engineer. This sets your kids up to succeed and feel confident in their ability to engineer.

Activities

The activities are designed to get kids thinking and working together to solve the unit's engineering design challenge. As the educator, it is your role to guide kids through these activities by encouraging them to pursue and communicate their own ideas, even if you think they may not work. In engineering, there are no right or wrong answers! Every problem has many possible solutions and multiple ways to reach them.

Reflect

Each adventure includes 5-10 minutes at the end for kids to communicate with their peers by sharing their work. This gives kids the chance to discuss new ideas, think about their own work and the work of others, and reflect on what was learned. Group reflection can help reduce competition by encouraging kids to support each other as they move through the Engineering Design Process. For more individual reflection, each adventure also includes time for kids to record thoughts and ideas in their Engineering Journal.

Engineering Journals

Make a copy of the Engineering Journal for each kid as you begin working on this EA unit. The Engineering Journal is a central location for kids to record their thoughts and ideas as they move through the unit. It includes recording pages that will guide kids through the Engineering Design Process, poses questions, and prompts kids to reflect on their learning. The 5-10 minutes kids spend with their journals during each adventure will allow them to create a personalized record of their engineering learning.

There are a few ways you can use the Engineering Journal. You may want to have groups share one Engineering Journal as a central recording spot for all group data and findings. This allows group members who enjoy writing and recording to do so. You may also encourage groups to share the responsibility by having group members rotate who records for each adventure.

The back page of each Engineering Journal is a passport page from the location in which the unit takes place. Kids are encouraged to stamp the passport page when they finish a unit and collect the pages from all of the units they have completed.

Alternate Prep Adventures

The two prep adventures *What is Engineering?* and *What is Technology?* introduce kids to engineering and technology. *What is Engineering?* gives kids the chance to collaborate, experience a mini hands-on engineering challenge, share out their designs, and learn about the Engineering Design Process. This adventure sets the stage for what they can expect in the rest of the unit.

What is Technology? has kids interact with technologies, working with the definition that a technology is any thing designed by humans to help solve a problem. Most kids think of technology as things that can be plugged into the wall. They do not realize the items that they interact with everyday, including pencils, paper, and water bottles, are also technologies. This activity introduces the definition of technology they will refer to as they engineer their own technologies to solve the problem presented in the unit.

There are alternate activities for both of these adventures available online at www.engineeringadventures.org. If kids complete multiple units, you may want to use an alternate activity to refresh the concepts in these activities. There may also be an activity that is more active or would be a better fit for the kids in your program. If you have questions about these activities, please email engineeringadventures@mos.org.

What You Need to Know **Before** Teaching an EA Unit

Engineering is fun.

The EA team hears this from many OST educators and kids. Engineering is really a way of problem solving—a way of thinking about the world—that is often very fun and creative. Any time you need to solve a problem in order to reach a goal, you are engineering.

There are no right or wrong answers.

There are often many great ways to solve the same problem. Not only is this a good engineering lesson for the kids in your program, it is a good life lesson.

It is okay to try it out!

It can be very helpful to try out the engineering challenge yourself—either beforehand or right alongside the kids in your program as they work through the adventures. This can help you understand the challenges the kids might face.

Scheduling the Adventures

Each adventure requires 45-60 minutes of teaching time. We recommend that you budget at least 9-10 hours in order to complete this unit, as some adventures may occasionally go longer than expected.

You can schedule this unit in several ways: once a week, several times a week, or daily. It is also possible to group certain adventures together. The chart below shows which adventures are easily taught together. Use this chart to help you plan your schedule.

Prep Adventure 1: What is Engineering? Tower Power Prep Adventure 2: What is Technology? Technology Detectives	2-3 hours
Adventure 1: Let's Get Rolling	1-1.5 hours
Adventure 2: Scrap Market Engineering Adventure 3: Recycled Racer Track	2-3 hours
Adventure 4: Creating a Recycled Racer *Adventure 4a: Air Power	2-3 hours
Adventure 5: Improving a Recycled Racer Adventure 6: Engineering Showcase: Recycled Racer Rally!	2-3 hours

Tips and Tricks for Teaching the Unit

Post a Daily Agenda

Giving kids a sense of the day's adventure will help them to plan ahead and manage their time during the activity.

Facilitate Teamwork

Being able to work well in teams is an important skill for any engineer. You may want to assign team roles to help kids if they struggle with teamwork. Possible roles include the recorder, the materials gatherer, the tester, and the presenter.

Timing

As groups are working, call out regular time intervals, so kids know how much time they have left to complete their task. This is especially helpful if kids have more than 20 minutes to work on a task. Letting them know when five minute increments have passed will allow them to budget their time and reassess where they are in their design.

Invite Others to the Showcase

The showcase, always the last adventure in the unit, is a big deal! This is a chance for kids to highlight the engineering they have done and share their accomplishments with others. Consider inviting families, program staff, and other kids to come to the showcase.

Mobile Apps

Mobile apps can be a fun way to engage kids in out-of-school time environments. The Engineering Adventures team has created iOS apps (compatible with most iPhones, iPod Touches, and iPads) that are designed to supplement the hands-on engineering experiences that your program provides.

You can download Engineering Adventures apps onto your personal device or devices that belong to your site. You may also choose to encourage kids to download the apps onto their devices so they may continue to practice their engineering skills on their own time. Encourage them to receive permission from parents before doing so.

Technology Flashcards

The *Technology Flashcards* app is designed to be used in conjunction with Prep Adventure 2. The app features a flashcards game that reinforces the idea that a technology is any thing designed by a human to help solve a problem. The game allows kids to learn from their misconceptions in real time by providing them with instant feedback on why selected items are classified as technologies or not.

Search for “Technology Flashcards” in the App Store or visit: http://tinyurl.com/flashcardsapp.

Messages from the Duo

The *Messages from the Duo* app is a new way for kids to listen to the audio communications from India and Jacob at the beginning of each adventure. Kids can use the scanner function in the app to scan the QR code at the top of each *Message from the Duo* page in the Engineering Journal. The audio of the message will play automatically as if India and Jacob are communicating directly to the kids over walkie-talkie! The app gives kids an opportunity to listen to the messages on their own for enhanced comprehension or to share with others. Educators may also choose to use the app as an alternative to a CD player or reading the messages aloud.

Search for “Messages from the Duo” in the App Store or visit: http://tinyurl.com/MFTDapp.

Background

Green Engineering

When an engineer is solving a problem using green engineering, it means that he or she is thinking about how to solve the problem in a way that prevents harm to the environment. Green engineering is a way of thinking that can be applied to any engineering problem.

Green engineers think about all the possible ways a technology might impact the environment when it is created, used, and eventually thrown away. At the beginning of the design process, green engineers would need to think about how the materials used to create a technology might affect the environment. If you will need a natural material, like wood, how would removing trees affect the area? If you will use a human-made material, would manufacturing it release any pollution into the air? The next step is thinking about how the technology will be used. How much energy will it require to make it work? Will using the technology create pollution? Finally, green engineers need to consider what might happen when the technology is no longer being used. If it is thrown into a landfill, are there chemicals or other pollutants that might contaminate the soil? Or could the technology be designed to biodegrade and cause minimal impact? At each step of the Engineering Design Process, green engineers help to think about ways to lessen the environmental impact of the technology.

Recycling Culture in Senegal

Senegal has a large recycling culture. People are very innovative and find ways to reuse most materials. At Scrap Markets, items that would otherwise be discarded are bought and used to create toys, sculptures, and household items to be sold. If you would like to see Senegalese recyclers in action, check out the following video: http://tinyurl.com/n283tqf. Go to the following link to see examples of recycled toys made by kids: http://tinyurl.com/nbkbvwa.

Dakar Rally

In this unit, kids are challenged to engineer a recycled racer. India and Jacob meet Amadou as he and his friends are creating a race track with different materials to mimic the Dakar Rally race course. Originally, the Dakar Rally started in Europe and ended in Dakar. Drivers would race their vehicles over large expanses of Europe and Africa, and had to be able to maneuver over different types of terrain. The Rally is now held in South America. If you would like to learn more, check out the official site of the Dakar Rally: http://tinyurl.com/69jy9c.

Core Concepts

1. Context: The people of Senegal have a culture of reuse and recycling. Reusing things that would otherwise be thrown away is a great way for people to help the environment since it helps alleviate some of the problems trash disposal causes.

2. Keeping Green: Because this is a green engineering unit, the more materials you and your kids can use from the recycling bin or the trash, the better. The whole point of green engineering is to impact the environment as little as possible. Encourage kids to think carefully about the material choices they are making.

Suggested Materials

Because kids should try to use materials from the recycling bin, it is hard to list all the possible materials you could gather for this unit. In order to make successful racers, kids will need at least three types of materials:

- Round things for wheels
- Rods for axles
- Boxes, bottles, or any lightweight object for racer bodies

Some suggested materials are listed in the Materials List, but kids should be encouraged to think creatively and to value reusing materials that would otherwise be thrown out. For more information on materials you or kids in your program might bring in, see the Materials List on p. xviii.

Online Resources

For more information about this unit, and other Engineering Adventures units, visit: www.engineeringadventures.org.

Vocabulary

Axle: A straight bar that passes through the center of a wheel.

Green engineer: An engineer who thinks about all of the possible ways a technology might impact the environment when it is created, used, and eventually thrown away.

Engineer: Someone who uses his or her creativity and knowledge of math and science to design things that solve problems.

Engineering Design Process: The steps that engineers use to design something to solve a problem.

Salut: Pronounced “sa-loo.” Senegalese word for “Hello.”

Technology: Any thing designed by humans to help solve a problem.

Materials List

This kit is prepared for 8 groups of 3 kids.

Quantity	Item
Non-Consumable Items	
1	*Engineering Design Process* poster
1	*Messages from the Duo* audio CD or access to a computer
1	ramp (piece of cardboard or box top, approx. 2 ft. x 3 ft.)
1	stuffed animal toy
4	bins, appx. 16” x 12” x 7”
8	ruler, 12”
8	scissors
8	toy/matchbox cars
10	tubes, plastic, approx. 3/4” diameter, 8” length
20	bobbins
32	CDs
Consumable Items	
1	glue (optional)
1 roll	parchment paper
1	tape, cellophane
2 sheets	felt, 8.5” x 11”
2 sheets	sandpaper, 60 grit
8	berry baskets, plastic
8	tape, masking
10	corrugated cardboard, 12” x 12”
10	grocery bags, plastic
20	cups, paper, 5 oz.
20	cups, paper, 8 oz.
20	dowels, wooden, 1/4” x 12”
20	plates, paper, small
32	washers, 1/4”
32	washers, 1/2”
50 sheets	colored foam, 9” x 12”
50	index cards, white, 5” x 8”
100	coffee stirrers, plastic, 7”
100 sheets	construction paper
100	pipe cleaners
100	straws, regular size, no bend, 1/4” diameter

Materials List, continued

Quantity	Item
Consumable Items	
100	straws, jumbo size, 1/2” diameter
800	index cards, 3” x 5”, white
NOT INCLUDED IN KIT	
1	CD player, MP3 player, or iOS device
1	chart paper
1	clock/timepiece for scheduling
1	cloth or bag large enough to cover technologies, see p. 9
1	rock or leaf
6	books or blocks to create 6”-8” tall stack, see p. 15
8	boxes (cereal, pasta, etc.)
8	juice cartons/soda bottles
8	technologies, see p. 9
30	markers/crayons

Please note:

1. Within the unit, the same quantities of materials for the Scrap Market are listed for each adventure. You do not need to restock the Scrap Market for each adventure. Just put out any materials left from previous adventures.

2. As this is a green engineering unit, please encourage kids and staff members to bring in and use materials from home or school that would otherwise be thrown away. Add materials into the Scrap Market throughout the adventures, and make sure to let the kids know when things have been added.

   You may choose to replace many of the materials listed with recycled items. There are a few specific materials that are necessary to complete the unit, in addition to the materials listed as not included in the kit. The rest of the materials listed can be items that would otherwise be recycled or thrown away. Use the chart on the next page for ideas about the types of materials to collect. You should have materials that could fall into the following categories: wheels, axles, racer bodies, and other. These items could range from old CDs and scrap paper to cereal boxes, sticks, and water bottles.

   Necessary Materials:
   - *Engineering Design Process* poster
   - *Messages from the Duo* audio CD, app, or access to a computer
   - 1 pair of scissors per group

Materials List, continued

- 1 ramp (piece of cardboard or box top, approx. 2 ft. x 3 ft.)
- 1 roll of tape per group
- 1 ruler per group
- 1 small stuffed animal
- 1 small toy car per group
- 4 bins (appx. 16” x 12” x 7”)
- 100 index cards per group
- Parchment or wax paper (the group can choose the length of the track, but we suggest at least 8 feet long)
- If completing Adventure 4a: 10 plastic grocery bags, 30 sheets of construction or scrap paper, 50 index cards (5” x 8”)

Activity 1 has a wheel and axle template with specific materials listed, but kids can use this time to explore different ways to make wheels and axles with the discarded materials that have been collected. The templates can be used to help guide kids’ designs or not used at all.

3. Possible additional materials to add to the Scrap Market are listed below.

Additional Materials You Might Add to the Scrap Market

Possible Wheels	Possible Axles	Possible Racer Bodies
bobbins	coffee stirrers	cardboard boxes (cracker, cereal, shoe, etc.)
CDs	dowels	cardboard sheets (that can be cut)
cup lids	paper (rolled into a tube)	paper towel tubes
cardboard sheets (that can be cut)	paper towel tubes	plastic deli containers
paper or plastic cups (large and small)	pencils or pens	soda bottles or juice cartons
paper or plastic plates	skewers	
plastic deli containers or yogurt containers	straws	
soda cans	toilet paper tubes	
washers		

National Education Standards

Engineering Adventures (EA) units are written with the goal of teaching engineering skills and critical thinking practices. Many EA units also touch upon a variety of science topics and principles. The engineering standards taught in this unit and the science topic links in this unit are noted below.

		Prep Adventure 1: What is Engineering? Tower Power	Prep Adventure 2: What is Technology? Technology Detectives	Adventure 1: Let's Get Rolling	Adventure 2: Scrap Market Engineering	Adventure 3: Recycled Racer Track	Adventure 4: Creating a Recycled Racer	Adventure 4a (Optional): Air Power	Adventure 5: Improving a Recycled Racer	Adventure 6: Engineering Showcase: Recycled Racer Rally!
National Science Education Standards	Science as Inquiry	✓					✓	✓	✓	
	Physical Science			✓	✓		✓	✓	✓	✓
	Life Science									
	Earth and Space Science									
	Science and Technology	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Science in Personal and Social Perspectives			✓	✓	✓	✓	✓	✓	✓
	History and Nature of Science									
ITEEA	The Nature of Technology		✓	✓	✓	✓	✓	✓	✓	✓
	Technology and Society			✓	✓	✓	✓	✓	✓	✓
	Design	✓		✓	✓	✓	✓	✓	✓	✓
	Abilities for a Technological World	✓		✓	✓	✓	✓	✓	✓	✓
	The Designed World									

		Prep Adventure 1: What is Engineering? Tower Power	Prep Adventure 2: What is Technology? Technology Detectives	Adventure 1: Let's Get Rolling	Adventure 2: Scrap Market Engineering	Adventure 3: Recycled Racer Track	Adventure 4: Creating a Recycled Racer	Adventure 4a (Optional): Air Power	Adventure 5: Improving a Recycled Racer	Adventure 6: Engineering Showcase: Recycled Racer Rally!
Next Generation Science Standards (Gr. 3-5)	3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.			✓	✓		✓	✓	✓	✓
	3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	✓		✓	✓	✓	✓	✓	✓	✓
	3-5-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	✓		✓	✓		✓	✓	✓	✓
	3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	✓			✓		✓		✓	✓

How to Recognize Success Rubric

How do you know if you are leading an Engineering Adventures activity successfully? This tool identifies three elements of success and highlights how the Adventure Guide supports you in setting this up with your kids.

Elements of success	What does this look like?	How does the guide help me facilitate this?
Kids were engaged and challenged by the activity. They persisted through difficulties.	• Kids are on-task. • Kids are trying out their ideas. • Kids identify what is working well in their designs. • Kids troubleshoot their own work. • Kids *improve* their designs.	• Use the Message from the Duo to **set a real-world context** that will engage kids in the activity. • Use the bold prompts to **ask open-ended questions** to help kids troubleshoot their work. • Use the bold prompts to **ask kids about what they think is working well** in their designs and what they would like to *improve*. This will help kids feel more confident about their problem-solving abilities.
Kids did most of the talking, sharing their ideas with each other during the entire activity.	• Kids bring their own ideas to the activity and are comfortable sharing them. • Kids brainstorm and debate within their groups. • Kids share their designs with others. • Kids talk about how their ideas are changing over time.	• Use the bold prompts in the guide to **encourage kids to share and explain their thinking**. • Have kids **work in groups** so they can brainstorm and *create* a design together. • Use the bold prompts in the Reflect section to **help kids share their new ideas about designs.**
Kids value their engineering work as a process, not just as the end result.	• Kids go beyond talking about their design to talking about how they thought of it and why they designed it. • Kids use the Engineering Design Process to describe their actions.	• Use the bold prompts in the guide to **ask kids how they use the Engineering Design Process.** Spending time talking and thinking about their process will help kids see the value in it. • Use the bold prompts to **ask all kids about *improving*** their designs, even if their designs are working well. • **Encourage kids to reflect individually** in their Engineering Journals to give them time for their experiences to sink in and be remembered.

How to Recognize Success Rubric Template

How do you know if you are leading an Engineering Adventures activity successfully? This tool will help you keep track of your kids' successful moments and will ask you to identify how your own actions enabled your kids to succeed.

Date: Adventure:

Elements of success	Evidence: Did I see this during the activity?	What was my role in making this happen?
Kids were engaged and challenged by the activity. They persisted through difficulties.		
Kids did most of the talking, sharing their ideas with each other during the entire activity.		
Kids value their engineering work as a process, not just as the end result.		

Dear Family, Date: _____

We are beginning an engineering unit called Go Green: Engineering Recycled Racers, which is part of the Engineering Adventures curriculum developed by the Museum of Science, Boston. Engineering Adventures is a curricular program that introduces children to engineering and the engineering design process. Throughout this unit, children will learn about green engineering and work to engineer toy race cars made out of recycled materials. The unit is set in a real-world context: children will learn about the recycling culture in Senegal and the toys children make there.

There are many reasons to introduce children to engineering:

- **Engineering projects reinforce topics children are learning in school.** Engaging students in hands-on, real-world engineering experiences can enliven math, science, and other content areas.
- **Engineering fosters problem-solving skills**, including problem formulation, creativity, planning, and testing of alternative solutions.
- **Children are fascinated with building and with taking things apart to see how they work.** By encouraging these explorations, we can keep these interests alive. Describing their activities as "engineering" when children are engaged in the natural design process can help them develop positive associations with engineering, and increase their desire to pursue such activities in the future.
- **Engineering and technological literacy are necessary for the 21st century.** As our society increasingly depends on engineering and technology, our citizens need to understand these fields.

Because engineering projects are hands-on, materials are often required. Several materials necessary to this unit are listed below. If you have any of these materials available, please consider donating them to us.

If you have expertise about green engineering or Senegal, or have any general questions or comments about the engineering and design unit we are about to begin, please let me know.

Sincerely,

If you have any of the following materials available and would like to donate them, I would greatly appreciate having them by the following date: _____ . Thank you!

_____ _____

_____ _____

_____ _____

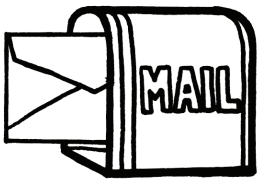
What is Engineering? Tower Power

Overview: Kids will engineer an index card tower that will support a stuffed animal.

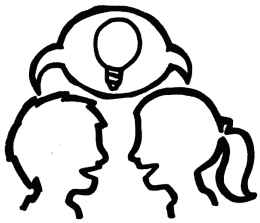
Note to Educator: Who are engineers? Engineers are people who use their creativity and knowledge of math and science to design things that solve problems. Today, kids will be engineers as they use the Engineering Design Process to design towers.

Find alternate versions of this activity at www.engineeringadventures.org/resources.

Duo Update (5 min)

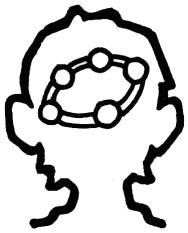


Set the Stage (10 min)



Activity (30 min)

Reflect (5 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 1 or Engineering Journal, p. 1
- ☐ *Engineering Design Process* poster
- ☐ *Heightened Emotions*, this guide, p. 7
- ☐ 1 small stuffed animal

For each group of 3-5 kids:

- ☐ at least 1 foot of masking tape
- ☐ 1 pack of index cards (about 100 cards)
- ☐ 1 pair of scissors
- ☐ 1 ruler

For each kid:

- ☐ Engineering Journal

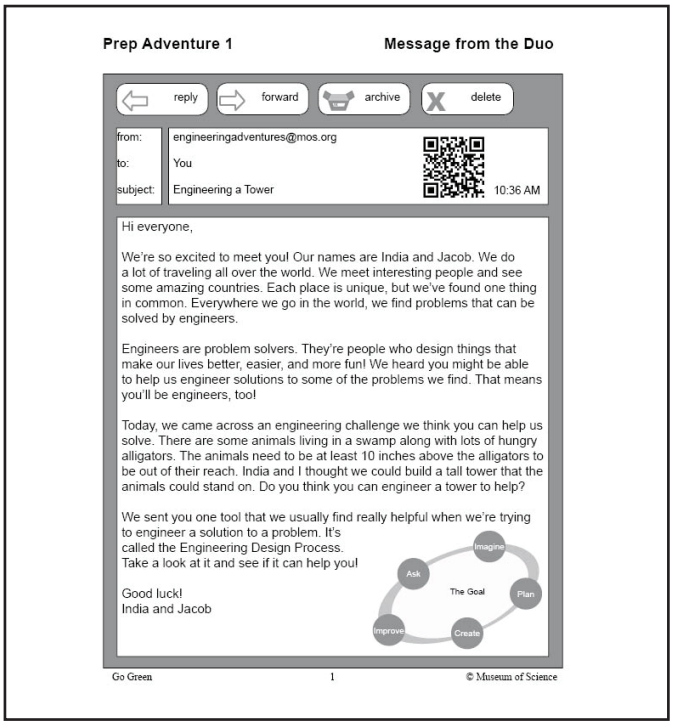
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Make samples of the cards found on *Building with Cards,* p. 2 in the kids' Engineering Journals.

Journal Pages for Prep Adventure 1

Message from the Duo, p. 1



Prep Adventure 1 — Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Engineering a Tower
10:36 AM

Hi everyone,

We're so excited to meet you! Our names are India and Jacob. We do a lot of traveling all over the world. We meet interesting people and see some amazing countries. Each place is unique, but we've found one thing in common. Everywhere we go in the world, we find problems that can be solved by engineers.

Engineers are problem solvers. They're people who design things that make our lives better, easier, and more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

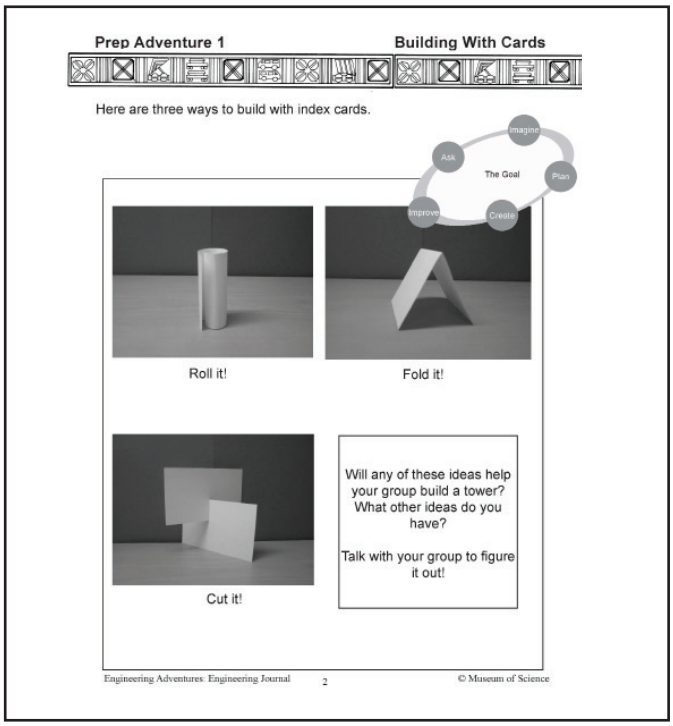
Today, we came across an engineering challenge we think you can help us solve. There are some animals living in a swamp along with lots of hungry alligators. The animals need to be at least 10 inches above the alligators to be out of their reach. India and I thought we could build a tall tower that the animals could stand on. Do you think you can engineer a tower to help?

We sent you one tool that we usually find really helpful when we're trying to engineer a solution to a problem. It's called the Engineering Design Process. Take a look at it and see if it can help you!

Good luck!
India and Jacob

Go Green 1 © Museum of Science

Building with Cards, p. 2



Prep Adventure 1 — Building With Cards

Here are three ways to build with index cards.

Roll it!

Fold it!

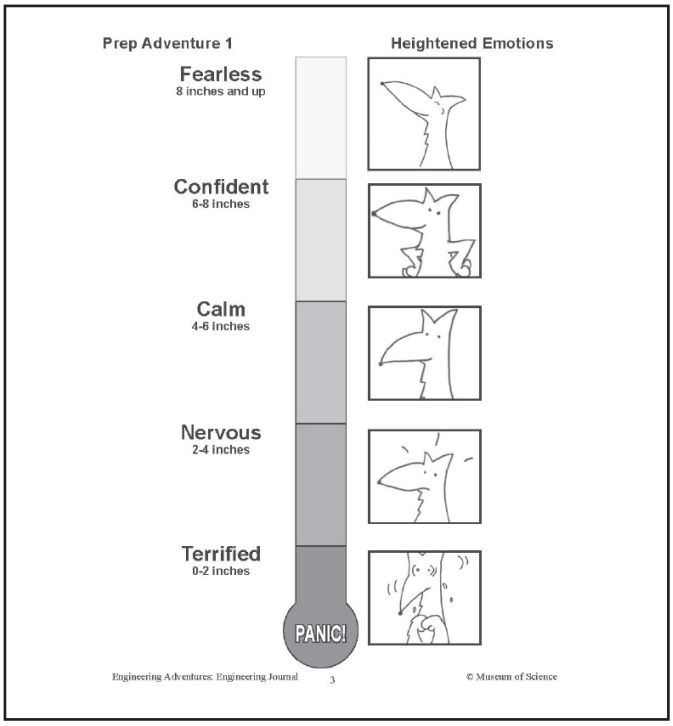
Cut it!

Will any of these ideas help your group build a tower? What other ideas do you have?

Talk with your group to figure it out!

Engineering Adventures: Engineering Journal 2 © Museum of Science

Heightened Emotions, p. 3



Prep Adventure 1 — Heightened Emotions

Fearless
8 inches and up

Confident
6-8 inches

Calm
4-6 inches

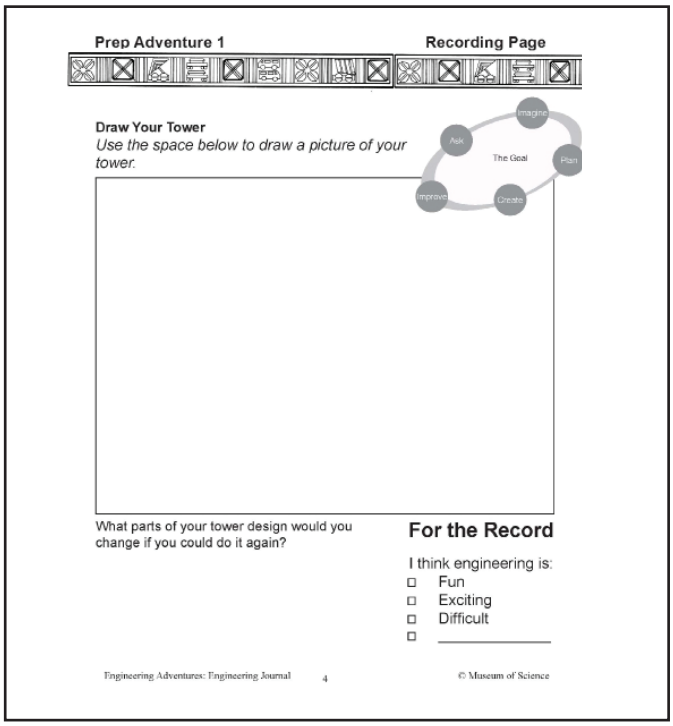
Nervous
2-4 inches

Terrified
0-2 inches

PANIC!

Engineering Adventures: Engineering Journal 3 © Museum of Science

Recording Page, p. 4



Prep Adventure 1 — Recording Page

Draw Your Tower
Use the space below to draw a picture of your tower.

What parts of your tower design would you change if you could do it again?

For the Record

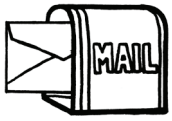
I think engineering is:

- ☐ Fun
- ☐ Exciting
- ☐ Difficult
- ☐ _____

Engineering Adventures: Engineering Journal 4 © Museum of Science

What is Engineering? Tower Power

Kids will learn:
- the Engineering Design Process is a tool they can use to help solve problems.



Present the Message from the Duo (5 min)

1. Tell kids that India and Jacob are a brother and sister team who travel the world. They find problems and solve them using engineering.
2. Explain that India and Jacob have sent the kids a message about a problem they would like them to solve. Have kids turn to *Message from the Duo*, p. 1 in their Engineering Journals, for more details. Play track 1.

Set the Stage (5 min)

1. Tell kids that today they are going be engineers and use the Engineering Design Process to solve India and Jacob's problem.
2. To check for understanding, ask:
   - **What do India and Jacob need us to engineer?** *A tower to lift the animal up 10 inches, so it does not get eaten by alligators.*
3. Show groups the *Engineering Design Process* poster and tell them they are going to *ask* questions about the problem, *imagine* ways to solve it, *plan* a design, *create* and test it, and then think about ways to *improve* it.

Imagine (5 min)

1. Tell kids it is time to look at the materials they can use and *imagine* different ways to make them work.
2. Split kids into groups of 3-5 and give each group a few index cards, scissors, ruler, and tape. Ask:
   - **Can you *imagine* any ways you could use these materials to engineer a tower?**
3. If your kids want to see examples, show them the index card samples you prepared or have them look at *Building with Cards*, p. 2 in their Engineering Journals. Ask:
   - **Do you think any of these ideas might work well? Why?**

Plan and Create (at least 20 min)

1. Tell kids it is time to *plan* and *create* their towers.
2. Show the stuffed animal and explain that:
   - The challenge is to work in groups to engineer a tower that can hold the animal 10 inches in the air for at least 10 seconds.
   - Each group will have (at least) 20 minutes.
   - Groups can only use index cards and tape in

Tip: If you can, you may want to offer more time for this challenge.

the tower. The scissors and ruler are tools only and cannot be used in the tower.
    - Groups can hold the stuffed animal briefly, but they cannot test it on their tower until the 20 minutes are up.
3. Give each group a pack of index cards and let them begin.
4. As groups work, circulate around the room. Ask questions like:
    - **Why do you think your design will work well?**
    - **Which step of the Engineering Design Process are you using right now? How do you know?**

Tip: You may choose to offer unlimited tape, or to challenge groups by limiting the tape to one or two feet.

Tower Showcase (10 min)

1. Have each group present their tower. Ask each group questions like:
    - **Can you tell me about your design?**
    - **Which steps of the Engineering Design Process did your group use?**
2. Use a ruler to measure the group's tower. Compare the measurement to the diagrams on *Heightened Emotions*. Give one kid from the group the stuffed animal and have him or her place it on top of their tower. Count to 10 and observe what happens. Whether or not their tower stands, ask:
    - **What parts would you *improve* if you could design your tower again? Why?**

Reflect (5 min)

1. Go through the *Engineering Design Process* poster with kids and have them talk about how they used each step to solve the problem. Ask questions like:
    - **How did you use this step of the Engineering Design Process to solve the problem?** *We* asked *about the challenge; we* imagined *ways to build with cards; we* planned *when we decided what design to use; and we* created *and* improved *when we built and fixed the tower.*
    - **Why do you think it is important to use these steps?** *It helps us keep track of our ideas and make sure we are meeting our goal.*
    - **Do you think you are an engineer?**
2. Tell kids that they have just used the same steps that engineers use to solve problems. This means that they are engineers, too! Tell kids they will have the opportunity to engineer solutions to even bigger problems with India and Jacob later on.
3. Give kids time to record their thoughts on *Recording Page*, p. 4 in their Engineering Journals. Allowing kids to draw and write about their work in this adventure will help them remember what they learned.

What is Engineering? Tower Power

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Engineering a Tower

10:36 AM

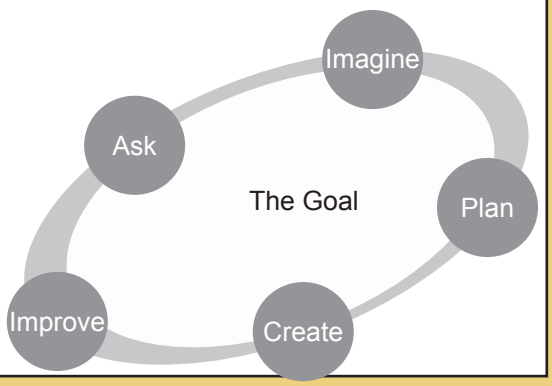
Hi everyone,

We're so excited to meet you! Our names are India and Jacob. We do a lot of traveling all over the world. We meet interesting people and see some amazing countries. Each place is unique, but we've found one thing in common. Everywhere we go in the world, we find problems that can be solved by engineers.

Engineers are problem solvers. They're people who design things that make our lives better, easier, and more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

Today, we came across an engineering challenge we think you can help us solve. There are some animals living in a swamp along with lots of hungry alligators. The animals need to be at least 10 inches above the alligators to be out of their reach. India and I thought we could build a tall tower that the animals could stand on. Do you think you can engineer a tower to help?

We sent you one tool that we usually find really helpful when we're trying to engineer a solution to a problem. It's called the Engineering Design Process. Take a look at it and see if it can help you!



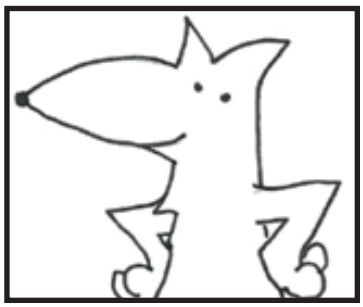
Good luck!
India and Jacob

Heightened Emotions

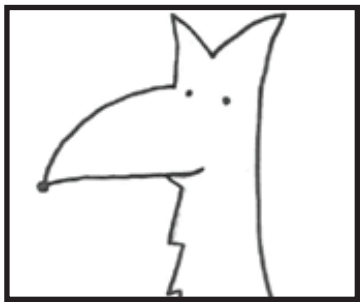
Prep Adventure 1
What is Engineering? Tower Power

Fearless
8 inches and up

Confident
6-8 inches



Calm
4-6 inches



Nervous
2-4 inches

Terrified
0-2 inches

PANIC!

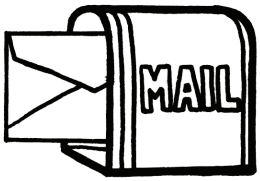
What is Technology? Technology Detectives

Overview: Kids will examine some technologies and *imagine* ways to *improve* them.

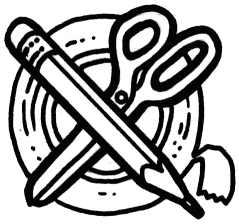
Note to Educator: Many people think of technologies as things that are only electronic or things that are "high-tech." Technology is actually any thing designed by humans to help solve a problem.

Find alternate versions of this activity at www.engineeringadventures.org/resources.

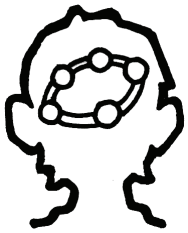
Duo Update (5 min)



Activity (15 min)



Reflect (20 min)



Materials

For the whole group:

- ☐ *Message from the Duo*, track 2 or Engineering Journal, p. 5
- ☐ *Engineering Design Process* poster
- ☐ a cloth or bag large enough to cover technologies
- ☐ chart paper or other writing space
- ☐ rock or leaf

Technologies (choose 8):

- ☐ bag
- ☐ book
- ☐ button
- ☐ construction paper
- ☐ dice
- ☐ electronic device (e.g. phone or calculator)
- ☐ glue stick
- ☐ hair clip
- ☐ hat
- ☐ juice box
- ☐ key
- ☐ roll of tape
- ☐ ruler
- ☐ scissors
- ☐ spoon
- ☐ stapler
- ☐ stuffed animal
- ☐ sweater
- ☐ water bottle

For each kid:

- ☐ Engineering Journal

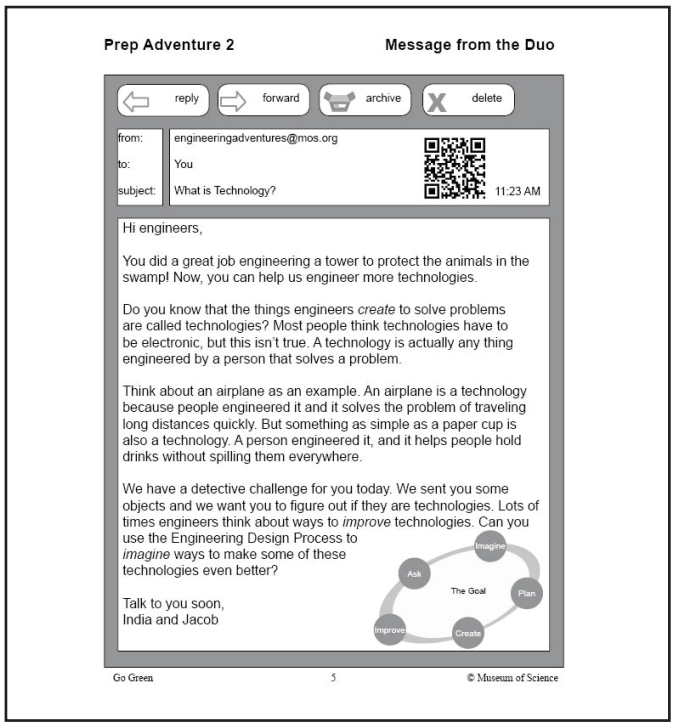
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Place 8 technologies (see above) on a table or floor and cover them with a cloth or bag.
4. On a sheet of large paper, make the *Technology Detective Tool* chart as shown on the next page.

Journal Pages for Prep Adventure 2

Message from the Duo, p. 5



Prep Adventure 2 — Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: What is Technology?
11:23 AM

Hi engineers,

You did a great job engineering a tower to protect the animals in the swamp! Now, you can help us engineer more technologies.

Do you know that the things engineers *create* to solve problems are called technologies? Most people think technologies have to be electronic, but this isn't true. A technology is actually any thing engineered by a person that solves a problem.

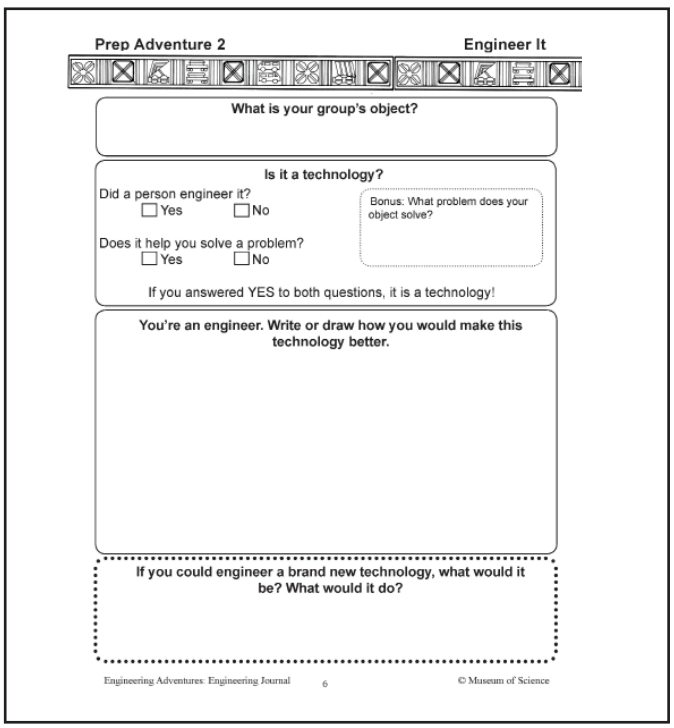
Think about an airplane as an example. An airplane is a technology because people engineered it and it solves the problem of traveling long distances quickly. But something as simple as a paper cup is also a technology. A person engineered it, and it helps people hold drinks without spilling them everywhere.

We have a detective challenge for you today. We sent you some objects and we want you to figure out if they are technologies. Lots of times engineers think about ways to *improve* technologies. Can you use the Engineering Design Process to *imagine* ways to make some of these technologies even better?

Talk to you soon,
India and Jacob

Go Green 5 © Museum of Science

Engineer It, p. 6



Prep Adventure 2 — Engineer It

What is your group's object?

Is it a technology?

Did a person engineer it? ☐ Yes ☐ No

Does it help you solve a problem? ☐ Yes ☐ No

Bonus: What problem does your object solve?

If you answered YES to both questions, it is a technology!

You're an engineer. Write or draw how you would make this technology better.

If you could engineer a brand new technology, what would it be? What would it do?

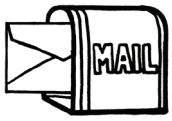
Engineering Adventures: Engineering Journal 6 © Museum of Science

Chart for Prep Adventure 2

Technology Detective Tool
Did a person engineer it?
Does it help you solve a problem?
If you answered YES to both, it is a technology!

What is Technology? Technology Detectives

Kids will learn:
- technology is any thing designed by people to help solve a problem.
- engineers *create* and *improve* technologies.



Present the Message from the Duo (5 min)

1. Tell kids that India and Jacob sent them a message with more information about what engineers do. Have kids turn to *Message from the Duo*, p. 5 in their Engineering Journals, to see the message. Play track 2.
2. To check for understanding, ask:
   - **India and Jacob said that a technology is any thing designed by people to solve a problem. What are some technologies you can think of?** *Accept all answers at this point.*
3. Give the kids about one minute to name all the technologies they can think of. If kids are only naming electronics, remind kids that India and Jacob mentioned that things like paper cups are also technology.

Tip: You may want to write down the technologies kids say, so you can refer back to it at the end of the adventure.

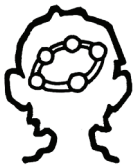
Undercover Detectives (15 min)

1. Explain to kids that now they will get the chance to think about more technologies—some that might surprise them.
2. Tell kids that under the cover on the table are some objects that might be technologies, or might not. They will use detective skills and teamwork to figure out which objects are technologies and what problems they solve.
3. Split kids into groups of 3-5.
4. Show them the *Technology Detective Tool chart* and explain they can use it to help figure out if the objects are technologies.
5. Pull the cloth and give groups a minute to decide what object they will take.
6. Have each group choose one object they would like to focus on in their groups.
7. Tell kids that they will now think like an engineer. They will use the *Technology Detective Tool* to decide whether their object is a technology. Then, they will *imagine* ways to *improve* the object they chose.
8. Have kids open to *Engineer It,* p. 6 in their Engineering Journals. Give

Tip: If kids are having trouble understanding what it means to engineer something, let them know that words like invent, design, and *improve* have a similar meaning. The more you use the term engineer, the more comfortable they will become with it!

groups about 10 minutes to complete the first three boxes. If groups are struggling, ask:

- **How can you make your technology more fun?**
- **How can you make your technology easier to use?**



Reflect (20 min)

1. Tell kids they are going to present their iechnology ideas to their fellow detectives. Encourage them to use the *Technology Detective Tool* chart and the *Engineer It* page in their journals to help them present. Ask each group:
   - **What is your technology?**
   - **How do you know it is a technology?** *Refer to the* Technology Detective Tool *chart.*
2. After all groups have presented, check for understanding about technology. Ask:
   - **Were all the objects you saw technologies? Why or why not?** *Yes, because people engineered them and they help solve a problem.*
3. Tell kids you have one more object for them to think about. Show them the rock/leaf. Ask:
   - **Is this a technology? Why or why not?** *No, because a person did not engineer it.*
4. Tell kids that they were engineers today by thinking about technologies that already exist and how to *improve* them. Engineers also *imagine* brand new technologies that no one has thought of before!
5. Have kids think about the engineering they have already done. Ask:
   - **Why do you think the tower you made before was a technology?**
6. Tell kids that in this unit they will be working in groups to engineer technologies that will help solve a problem.
7. Give kids a few moments to complete the last box on the *Engineer It* page of the journal. Thinking about things they might engineer in the future will help kids see themselves as engineers.

Tip: A rock, leaf, or other natural objects on their own are not technologies. If people turn those objects into tools, however, they could become technologies! For example, using a rock to grind corn or making it into an arrow head makes the rock a technology.

Tip: If you have enough time, encourage kids to share their ideas with a partner.

What is Technology? Technology Detectives

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	What is Technology?

11:23 AM

Hi engineers,

You did a great job engineering a tower to protect the animals in the swamp! Now, you can help us engineer more technologies.

Do you know that the things engineers *create* to solve problems are called technologies? Most people think technologies have to be electronic, but this isn't true. A technology is actually any thing engineered by a person that solves a problem.

Think about an airplane as an example. An airplane is a technology because people engineered it and it solves the problem of traveling long distances quickly. But something as simple as a paper cup is also a technology. A person engineered it, and it helps people hold drinks without spilling them everywhere.

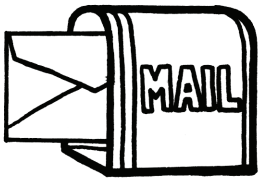
We have a detective challenge for you today. We sent you some objects and we want you to figure out if they are technologies. Lots of times engineers think about ways to *improve* technologies. Can you use the Engineering Design Process to *imagine* ways to make some of these technologies even better?

Talk to you soon,
India and Jacob

Overview: Kids will learn about the Recycled Racer Rally and that they will engineer toy cars from materials that would otherwise be thrown away. They will also build some example wheel systems and test how possible wheel materials roll.

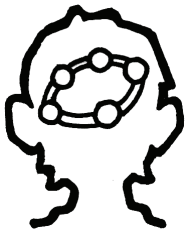
Note to Educator: In today's adventure, kids are following directions to build wheel systems. This experience of making wheels (and axles) that work will help them be successful in the next several adventures when they are asked to engineer recycled racers and wheels from a wider variety of materials.

Duo Update (5 min)



Activity (30 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 3 or Engineering Journal, p. 7
- ☐ *Engineering Design Process* poster
- ☐ chart paper/white board
- ☐ markers
- ☐ 1 bobbin
- ☐ 1 paper cup, small
- ☐ 1 paper cup, large
- ☐ 1 straw, regular size
- ☐ 1 box lid (about 2'x3') or other flat surface to use as a ramp
- ☐ books or blocks to create a 6"-8" tall stack

For each group of 3-5 kids:

- ☐ 2 CDs
- ☐ 2 straws, jumbo size
- ☐ 1 dowel
- ☐ 2 washers, 1/4"
- ☐ 1 pipe cleaner
- ☐ 1 pair of scissors

For each kid:

- ☐ Engineering Journal

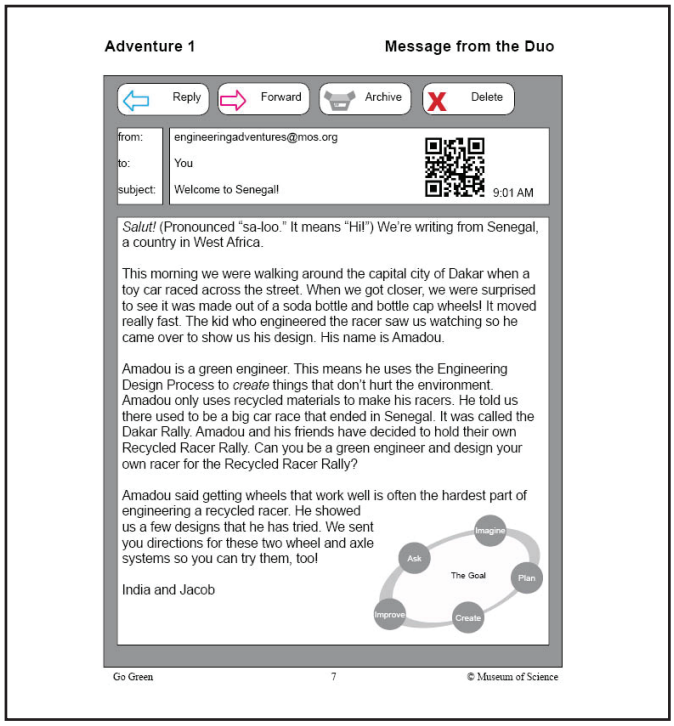
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Lay out all of the materials on a table.
4. Set up a ramp by creating a 6"-8" tall stack of books or blocks and propping up one end of the box lid (or other flat surface).

Journal Pages for Adventure 1

Message from the Duo, p. 7



Adventure 1 **Message from the Duo**

Reply | Forward | Archive | Delete

from: engineeringadventures@mos.org
to: You
subject: Welcome to Senegal!
9:01 AM

Salut! (Pronounced "sa-loo." It means "Hi!") We're writing from Senegal, a country in West Africa.

This morning we were walking around the capital city of Dakar when a toy car raced across the street. When we got closer, we were surprised to see it was made out of a soda bottle and bottle cap wheels! It moved really fast. The kid who engineered the racer saw us watching so he came over to show us his design. His name is Amadou.

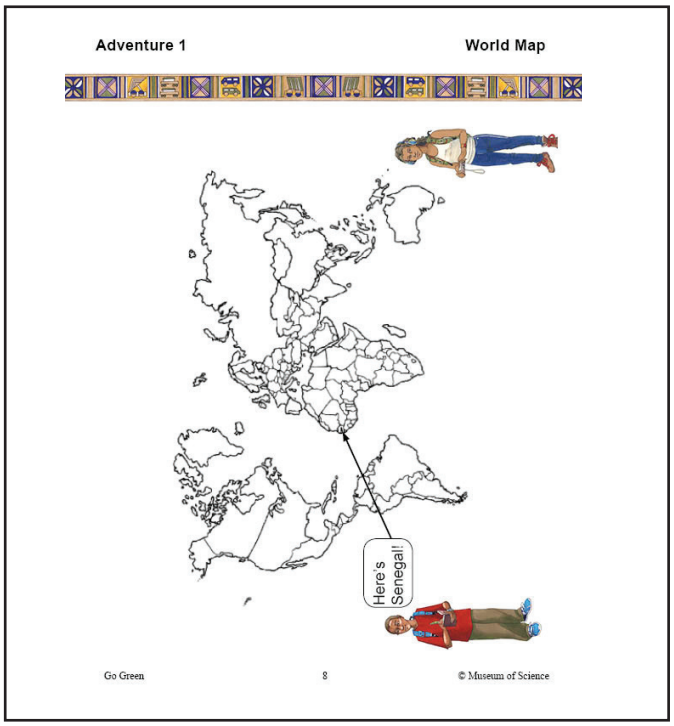
Amadou is a green engineer. This means he uses the Engineering Design Process to *create* things that don't hurt the environment. Amadou only uses recycled materials to make his racers. He told us there used to be a big car race that ended in Senegal. It was called the Dakar Rally. Amadou and his friends have decided to hold their own Recycled Racer Rally. Can you be a green engineer and design your own racer for the Recycled Racer Rally?

Amadou said getting wheels that work well is often the hardest part of engineering a recycled racer. He showed us a few designs that he has tried. We sent you directions for these two wheel and axle systems so you can try them, too!

India and Jacob

Go Green 7 © Museum of Science

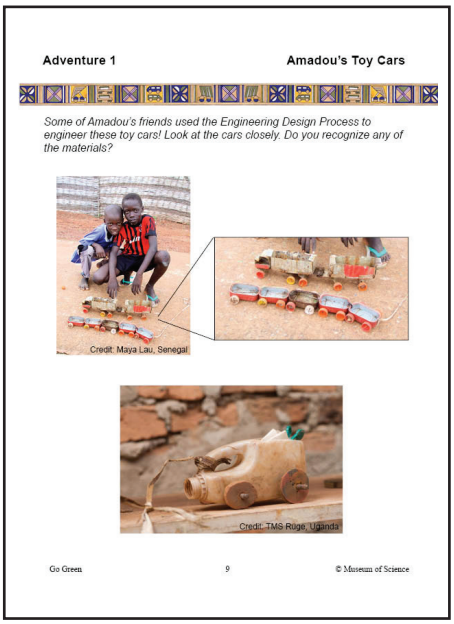
World Map, p. 8



Adventure 1 **World Map**

Go Green 8 © Museum of Science

Amadou's Toy Cars, p. 9



Adventure 1 **Amadou's Toy Cars**

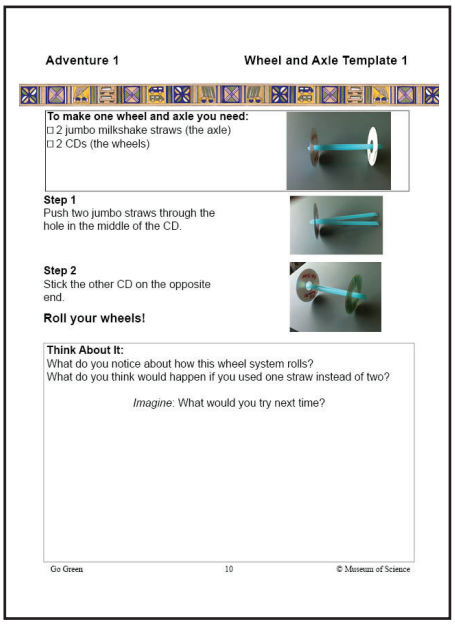
Some of Amadou's friends used the Engineering Design Process to engineer these toy cars! Look at the cars closely. Do you recognize any of the materials?

Credit: Maya Lau, Senegal

Credit: TMS Rüge, Uganda

Go Green 9 © Museum of Science

Wheel and Axle Template 1, p. 10



Adventure 1 **Wheel and Axle Template 1**

To make one wheel and axle you need:
☐ 2 jumbo milkshake straws (the axle)
☐ 2 CDs (the wheels)

Step 1
Push two jumbo straws through the hole in the middle of the CD.

Step 2
Stick the other CD on the opposite end.

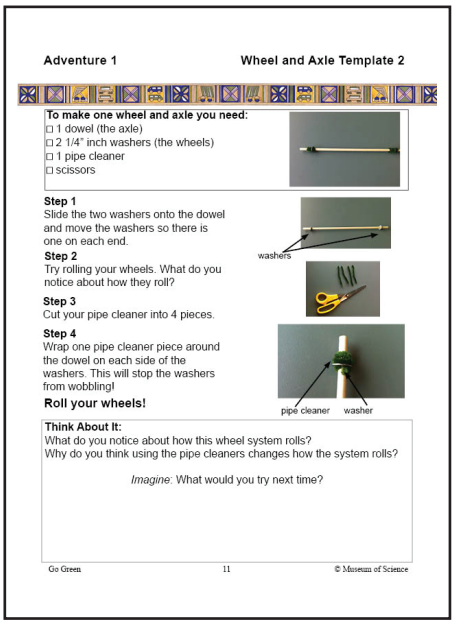
Roll your wheels!

Think About It:
What do you notice about how this wheel system rolls?
What do you think would happen if you used one straw instead of two?

Imagine: What would you try next time?

Go Green 10 © Museum of Science

Wheel and Axle Template 2, p. 11



Adventure 1 **Wheel and Axle Template 2**

To make one wheel and axle you need:
☐ 1 dowel (the axle)
☐ 2 1/4" inch washers (the wheels)
☐ 1 pipe cleaner
☐ scissors

Step 1
Slide the two washers onto the dowel and move the washers so there is one on each end.

Step 2
Try rolling your wheels. What do you notice about how they roll?

Step 3
Cut your pipe cleaner into 4 pieces.

Step 4
Wrap one pipe cleaner piece around the dowel on each side of the washers. This will stop the washers from wobbling!

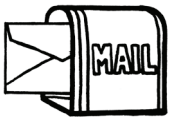
Roll your wheels!

Think About It:
What do you notice about how this wheel system rolls?
Why do you think using the pipe cleaners changes how the system rolls?

Imagine: What would you try next time?

Go Green 11 © Museum of Science

Kids will learn:
- many different materials can be used to make wheels or wheel systems, and each may have advantages and disadvantages.
- the *imagine* step is an important part of the Engineering Design Process.



Present the Message from the Duo (5 min)

1. Tell kids that India and Jacob sent a message about a special kind of toy car they saw while traveling in Senegal.
2. Have kids turn to *Message from the Duo*, p. 7 in their Engineering Journals, to follow along. Play track 3.
3. To check for understanding, ask:
   - **What does Amadou want us to do?** *Be green engineers and engineer a toy car out of recycled materials to race in the Recycled Racer Rally. Today, we will make some wheel and axle systems.*
4. Have kids look at *World Map*, p. 8 in their Engineering Journals, to find Senegal. Then, have them look at *Amadou's Toy Cars,* p. 9 in their Engineering Journals. Ask:
   - **What materials do you recognize?** *Bottles, caps, tin cans, etc.*
   - **What shapes or sizes might we want our wheels to be?** *For now accept all answers. Kids might say round, large, etc.*

Making Wheels and Axles (20 min)

1. Have kids take a look at *Wheel and Axle Templates*, pp. 10-11 in their Engineering Journals. Point out that the axles are the rods or sticks in the middle and the wheels are the cylindrical objects on the ends of the axles.
2. Have kids work in small groups. Encourage some groups to build from *Template 1* and some *Template 2*. They can build both if they have time.
3. Groups should send one group member to the Materials Table to gather supplies.
4. As kids are building, guide them to think about how their wheels and axles will work. Ask:
   - **How did the washer wheels roll with and without the pipe cleaners?** *They rolled both times, but the pipe cleaners helped the washers "stand up straight" and wobble less.*
   - **How did the CD wheels roll with only one straw as the axle?** *They were wobbly and rolled better with the two straws keeping them stable.*

Testing Wheels and Axles (10 min)

1. Once all kids have built at least one wheel and axle, tell kids they are going to get a chance to compare how they roll.
2. Prop up a box lid or other flat surface up about 6-8 inches on one end to

make a ramp at about a 45 degree angle.

3. Kids should take turns rolling their wheels and axles down the ramp and across the floor. Try rolling a couple at the same time so kids can compare differences. Ask:
   - **What types of differences did you see between the wheels and axles we made?**
   - **What other materials might you want to try making wheels out of?**
4. Show kids a bobbin, a paper cup, and a straw. Ask a volunteer to try rolling those materials down the ramp. Ask:
   - **What do you notice about how these wheel options roll? What is the same? What is different?** *The cups will likely not roll straight, the bobbins may roll quickly, etc.*
5. Let kids know that in the next adventure, they will be able to use more materials to engineer wheels, axles, and other parts of their racers. They will have to think about what size and material wheel they would like to use.

Reflect (10 min)

1. Tell kids they should take a few minutes to *imagine* what they would like to try next time. *Imagining* is an important part of the Engineering Design Process, and they will be able to *create* their ideas and test them in the next adventure.
2. Have kids work in pairs to fill in the "Think About It" section on *Template,* pp. 10-11 in their Engineering Journals. Having kids record their ideas will help them remember what they learned and apply it in the next adventure.
3. Gather kids together and ask a few volunteers to share what they *imagined*.
4. Tell kids that for the rest of this unit, they will work as teams of green engineers to engineer a racer that they can race in the Recycled Racer Rally. To engineer their racer, they will use the Engineering Design Process.
5. Have kids look at the *Engineering Design Process* poster. Ask:
   - **What steps of the Engineering Design Process did you use today?** *Common responses: We* asked *about wheels and* imagined *car designs.*
6. Have kids think about materials they are throwing away or recycling at home or school. Encourage them to bring these materials in for next time to use as part of their recycled racer designs.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Welcome to Senegal!

9:01 AM

Salut! (Pronounced "sa-loo." It means "Hi!") We're writing from Senegal, a country in West Africa.

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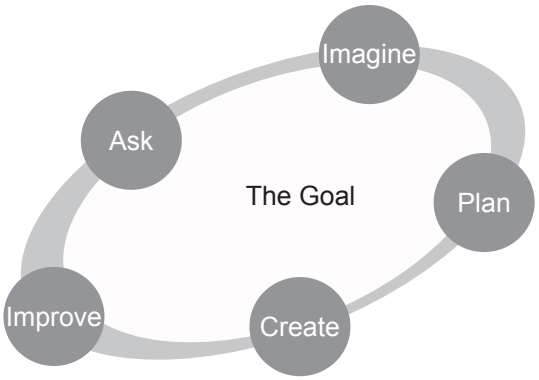
Amadou is a green engineer. This means he uses the Engineering Design Process to create things that don't hurt the environment. Amadou only uses recycled materials to make his racers. He told us there used to be a big car race that ended in Senegal. It was called the Dakar Rally. Amadou and his friends have decided to hold their own Recycled Racer Rally. Can you be a green engineer and design your own racer for the Recycled Racer Rally?

Amadou said getting wheels that work well is often the hardest part of engineering a recycled racer. He showed us a few designs that he has tried. We sent you directions for these two wheel and axle systems so you can try them, too!



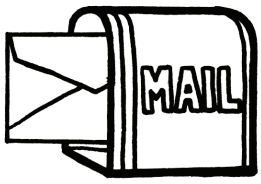
India and Jacob

Scrap Market Engineering

Overview: Kids will begin engineering their recycled racer designs and will be able to design their own wheel systems using what they learned during Adventure 1.

Note to Educator: Kids will make their own Scrap Market by sorting materials into various bins based on their possible function. See the Materials List, pp. xviii-xx, for tips on discarded materials to gather. **Be sure to save the Scrap Market and recycled racers kids design for further use in upcoming adventures.**

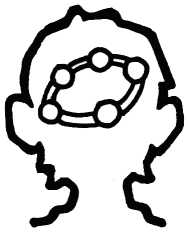
Duo Update (5 min)



Ask (15 min)

Create (20 min)

Reflect (5 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 4 or Engineering Journal, p. 12
- ☐ *Engineering Design Process* poster
- ☐ ramp (from Adventure 1)
- ☐ chart paper/white board
- ☐ markers

Scrap Market:

- ☐ 4 bins
- ☐ 8 boxes (cereal, pasta, etc.)
- ☐ 8 juice boxes/soda cans
- ☐ 8 plastic berry baskets
- ☐ 10 cardboard sheets, 12” x 12”
- ☐ 10 plastic tubes
- ☐ 20 bobbins
- ☐ 20 paper cups, 5 oz.
- ☐ 20 paper cups, 8 oz.
- ☐ 20 plates, paper
- ☐ 20 wooden dowels
- ☐ 32 CDs
- ☐ 32 washers, 1/4”
- ☐ 32 washers,1/2”
- ☐ 50 sheets foam
- ☐ 70 sheets construction paper
- ☐ 100 coffee stirrers
- ☐ 100 pipe cleaners
- ☐ 100 straws, jumbo size
- ☐ 100 straws, regular size

For each group of 3-5 kids:

- ☐ scissors
- ☐ small toy car
- ☐ masking tape

For each kid:

- ☐ Engineering Journal

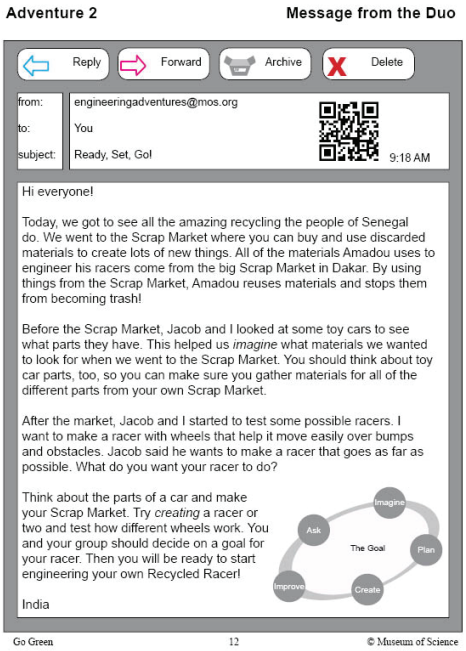
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Lay out all the Scrap Market materials on a table.
4. Make labels saying wheels, axles, and racer bodies for bins.

Journal Pages for Adventure 2

Message from the Duo, p. 12



Adventure 2 **Message from the Duo**

Reply | Forward | Archive | Delete

from: engineeringadventures@mos.org
to: You
subject: Ready, Set, Go!
9:18 AM

Hi everyone!

Today, we got to see all the amazing recycling the people of Senegal do. We went to the Scrap Market where you can buy and use discarded materials to create lots of new things. All of the materials Amadou uses to engineer his racers come from the big Scrap Market in Dakar. By using things from the Scrap Market, Amadou reuses materials and stops them from becoming trash!

Before the Scrap Market, Jacob and I looked at some toy cars to see what parts they have. This helped us *imagine* what materials we wanted to look for when we went to the Scrap Market. You should think about toy car parts, too, so you can make sure you gather materials for all of the different parts from your own Scrap Market.

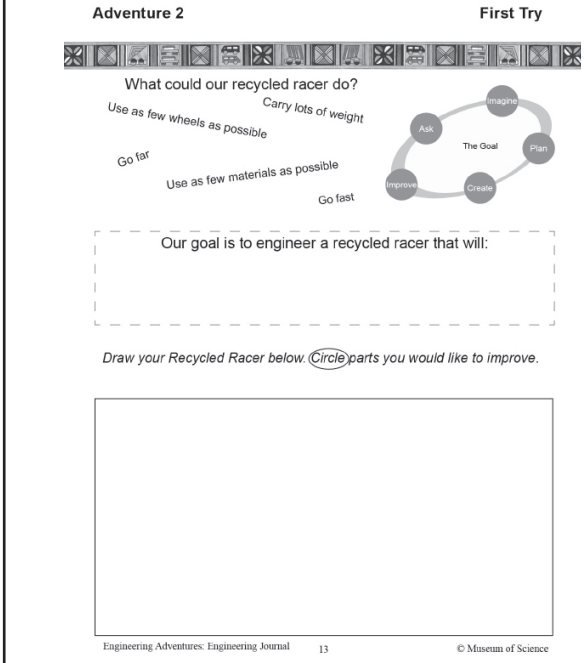
After the market, Jacob and I started to test some possible racers. I want to make a racer with wheels that help it move easily over bumps and obstacles. Jacob said he wants to make a racer that goes as far as possible. What do you want your racer to do?

Think about the parts of a car and make your Scrap Market. Try *creating* a racer or two and test how different wheels work. You and your group should decide on a goal for your racer. Then you will be ready to start engineering your own Recycled Racer!

India

Go Green 12 © Museum of Science

First Try, p. 13



Adventure 2 **First Try**

What could our recycled racer do?

Use as few wheels as possible
Carry lots of weight
Go far
Use as few materials as possible
Go fast

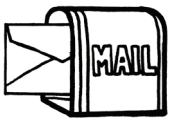
Our goal is to engineer a recycled racer that will:

Draw your Recycled Racer below. Circle parts you would like to improve.

Engineering Adventures: Engineering Journal 13 © Museum of Science

Scrap Market Engineering

Kids will learn:
- cars have different parts.
- they can use the Engineering Design Process to engineer a racer.
- it is okay if their first engineered racer needs improvements.



Present the Message from the Duo (5 min)

1. Tell kids that today they will get the chance to experiment with building some racers. India sent a message with more details. Have kids turn to *Message from the Duo*, p. 12 in their Engineering Journals. Play track 4.
2. To check for understanding, ask:
   - **What is India asking you to do?** *Make our own Scrap Market, test out some different racers and wheels, and decide on a goal for our racer.*

See It: See Senegal and the recycling culture: http://tinyurl.com/oczo5j4.

Ask: A Closer Look at Cars (5 min)

1. Tell kids that before they think about engineering their own racers, they will look at some model cars.
2. Give each group of 3-5 kids a toy car to look at. Encourage them to observe all of the parts carefully. Ask:
   - **What parts do you see?** *Brainstorm a list; write it on the board or chart paper. Encourage kids to look carefully at the wheels, axles, and body of the car, since they will be working more with these parts in the next section.*
   - **Which parts help the car move?** *Circle the items on the list that kids suggest.*

Ask: Making the Scrap Market (10 min)

1. Now that they have looked at a toy car and thought about the parts of the car, tell kids they will organize a Scrap Market like the one India and Jacob talked about. It will include materials they will be able to use to engineer their own racers.
2. Have kids stand in a circle around the table of materials. Ask:
   - **Do you see anything that you could use to make a wheel?** *Have some volunteers put the suggested items in a bin, and label it "wheels."*
   - **Repeat the same question with "axles" and "racer bodies."**

Tip: Setting up the Scrap Market should not take too long. If this part of the adventure is starting to drag, just sort one or two materials into each bin and ask for volunteers to help sort remaining materials while other kids move on.

- **What other materials do you see? What could you use them for?** *Sort materials as kids suggest into the final bin and label it with the uses they suggested (windows, bumpers, etc.).*

Create! (20 min)

1. Tell kids their groups will now get to test out a few example racers. These do not need to be their final designs. They should try to test a few different ideas to get a sense for what works well.
2. Remind kids that just like India, Jacob, and Amadou, they might have some trouble with certain parts of the racer, but in the following adventures they will have plenty of time to *improve*.
3. Split kids into groups of 3-5.
4. Let kids begin engineering. As groups are working, ask:
   - **What is working well in your design?**
   - **Which parts of your racer need more work?**
5. When groups are ready to test, let them know they should place the racer on top of the ramp, give it a gentle push to start, and carefully observe how their racer rolls.

Tip: Most groups likely will not have a working racer today, which is fine! They will have plenty of time to work on their wheels in the next adventures.

Reflect (5 min)

1. Collect the racers and have groups sort any materials they did not use back into the Scrap Market.
2. Now that groups have had a chance to do some experimentation with the types of racers and wheel systems they can *create* using the materials they have, each group should pick a goal for their Recycled Racer Design. They might want their racer to go far, be able to carry lots of weight, use as few materials as possible, go fast, etc. Give groups a few minutes to decide on the goal for their racer. Have groups record their goal on *First Try*, p. 13 in their Engineering Journals.
3. Gather kids together and show them the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process did you do today?** *We* asked *what would work for different parts of our racers,* imagined *how we could put materials together,* planned *and* created *our racers.*
4. Have kids complete *First Try*, p. 13 in their Engineering Journals. Having kids record their ideas will help them remember improvements they would like to make during the next adventure. Encourage kids to bring in recycled or discarded materials from home that can be added into the Scrap Market.

Tip: Having each group set their own goal helps build investment in the engineering challenge. For most groups, getting a racer that rolls well will be their first challenge. Once that has been accomplished, they can spend more time focused on their individual goal.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Ready, Set, Go!

9:18 AM

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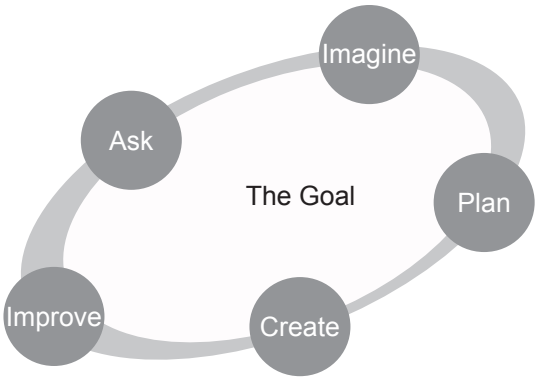
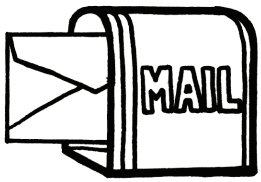


India

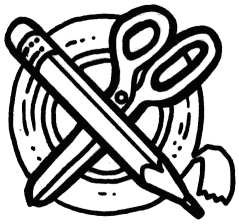
Overview: Kids will make a track for the Recycled Racer Rally and will share information about their goal and their racer designs with other groups.

Note to Educator: While kids should have the freedom to make their own decisions about what their race track will be like, you might want to remind them to think about whether the obstacles they add are realistic for their recycled racers to roll over.

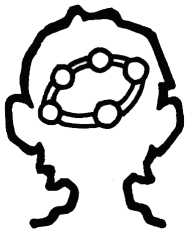
Duo Update (5 min)



Activity (25 min)



Reflect (15 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 5 or Engineering Journal, p. 14
- ☐ *Engineering Design Process* poster
- ☐ chart paper/white board
- ☐ markers

Track:

- ☐ 1 roll of parchment paper
- ☐ box lid or other ramp used in Adventure 1 (approx. 2' x 3')
- ☐ 2 sheets sandpaper
- ☐ 2 sheets foam
- ☐ 2 sheets felt
- ☐ 2 sheets construction paper
- ☐ 1 bottle of glue (optional)

For each group of 3-5 kids:

- ☐ Recycled Racer from Adventure 2
- ☐ tape

For each kid:

- ☐ Engineering Journal

Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Lay out all of the Track materials on a table.
4. Note that you will not need to put out the Scrap Market bins today.

Journal Pages for Adventure 3

Message from the Duo, p. 14

Adventure 3 **Message from the Duo**

Reply | Forward | Archive | Delete

from: engineeringadventures@mos.org
to: You
subject: A Recycled Rally Race Track
2:15 PM

Hey everyone,

We've been working away on our racers. Amadou had us take a break to help create a special track that we will use for our Recycled Racer Rally. He said that in the Dakar Rally racers would drive across flat plains, hilly jungles, and sandy deserts. We added some obstacles to the track for our racers to roll over. You should make your own track, too!

After we tried out the wheels and axles Amadou showed us, India started brainstorming tons of questions about wheels. She tested some big wheels first, and now she's testing small wheels. Then she started to ask about the number of wheels. Will lots of wheels make the car go far? Just a few wheels? We're still working to *create* wheels that help us meet the goals we decided on for our racers. Talking to Amadou and his friends to get advice has helped us a lot.

You can create your own track to use for your Recycled Racer Rally. Then, keep using the steps of the Engineering Design Process to engineer racers that meet your goal. Make sure to share what you find with each other!

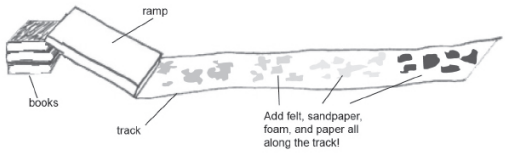
Jacob

Engineering Adventures: Engineering Journal 14 © Museum of Science

Making the Track, p. 15

Adventure 3 **Making the Track**

Glue different materials to the track. Use a box top or tape a piece of cardboard to a stack of books to create the ramp.



To make the track extra challenging, add texture by crumpling the materials you add and making bumps. What else can you add to the the track to make obstacles?

Brain Twister

- What landscape does each material represent on your track? What other materials could you add?

Engineering Adventures: Engineering Journal 15 © Museum of Science, 2013

Engineering Advice, p. 16

Adventure 3 **Engineering Advice**

Now that you have had a chance to talk with other engineers about your racer, do you think you will make changes? Write or draw below.

What part of the track will be the easiest for your racer to go over?

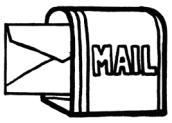
_____

What part of the track will be the most difficult for your racer to go over?

_____

Engineering Adventures: Engineering Journal 16 © Museum of Science

Kids will learn:
- the materials you use to *create* a technology (the recycled racers) impact what the technology can do (what the racers can roll over).
- the specific goal for a racer can impact many parts of the racer design.



Present the Message from the Duo (5 min)

1. If groups did not decide on a goal for their recycled racers at the end of the last adventure, have them do so before you begin today. They can record their goal on *First Try*, p. 13 in their Engineering Journals.
2. Tell kids that Jacob sent a message about the track their cars will race on.
3. Have kids turn to *Message from the Duo*, p. 14 in their Engineering Journals. Play track 5.
4. To check for understanding, ask:
   - **What is Jacob asking you to do?** *Make our track, keep* improving *our racers, and share what we find.*
   - **What steps of the Engineering Design Process will help you?** *We can* ask *questions about changing the wheels,* imagine *new things to try,* create *new wheels,* improve *what we tried before, etc.*

Making the Track (25 min)

1. Tell kids they are going to make a track like the one India and Jacob mentioned. Have kids visualize the plains, jungles, and deserts Amadou said Dakar Rally drivers would race over. Ask:
   - **What would the surface be like in the desert? Jungle? Plains?** *Answers might include sandy, bumpy with plants and tree roots, grassy, etc.*
2. Have kids take a look at the track and ramp directions on *Making the Track*, p. 15 in their Engineering Journals. Ask:
   - **What might be easy for our racers to roll over? Difficult?**
3. Show kids the parchment paper and explain that the paper forms the base of their track.
4. Demonstrate how to glue different materials to the parchment paper in order to create textures and obstacles.
5. Have kids construct the track and ramp. You might want to have small groups work on separate sections. Remind kids that their racers will need to roll over any obstacles they add to the track!

Tip: If your group does not finish making the track today, make the materials available for them to work with during the next adventure.

Reflect (15 min)

1. Tell kids they are going to share information about the racers and wheels

they have experimented so far, just as India and Jacob did with Amadou and his friends.

2. Have kids gather in their groups. Give them a few moments to come up with one good thing about their racer and one problem about their racer that they would like to share.
3. Have groups share their designs from the last adventure. Ask:
   - **What is the goal of your racer?**
   - **What about your design is working well? Not working well?**
   - **Now that we have made our track, how might you need to change your wheels?**
4. Encourage other groups to act as consulting engineers, giving suggestions about ways groups might fix things that are not working well. They may want to record ideas on *Engineering Advice*, p. 16 in their Engineering Journals.
5. Show kids the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process do you think will help you most as we continue to work on our racers?** *Many groups will likely need to continue* improving *their racers.*
6. Remind kids that they might want to bring in some recycled materials from home to add to the Scrap Market for next time.

Tip: If you have a large group or are short on time, pair groups together and have them share. They can take turns sharing their designs and acting as consulting engineers.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	A Recycled Rally Race Track

2:15 PM

Hey everyone,

We've been working away on our racers. Amadou had us take a break to help *create* a special track that we will use for our Recycled Racer Rally. He said that in the Dakar Rally racers would drive across flat plains, hilly jungles, and sandy deserts. We added some obstacles to the track for our racers to roll over. You should make your own track, too!

After we tried out the wheels and axles Amadou showed us, India started brainstorming tons of questions about wheels. She tested some big wheels first, and now she's testing small wheels. Then she started to ask about the number of wheels. Will lots of wheels make the car go far? Just a few wheels? We're still working to *create* wheels that help us meet the goals we decided on for our racers. Talking to Amadou and his friends to get advice has helped us a lot.

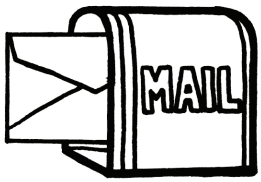
You can *create* your own track to use for your Recycled Racer Rally. Then, keep using the steps of the Engineering Design Process to engineer racers that meet your goal. Make sure to share what you find with each other!

Jacob

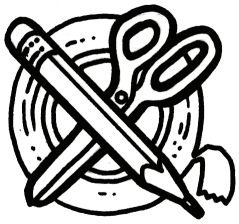
Overview: Kids will use their chosen goal and everything they have learned about wheels and recycled racers to begin engineering their racers.

Note to Educator: It can be hard for kids to share ideas with other groups, but encourage them to learn from each other. Point out that engineers often work together and share ideas to make their designs the best they can be!
Take the time to read through "Notes on Troubleshooting," found on p. 36 of this guide, before you begin the adventure.

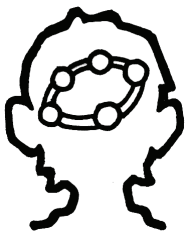
Duo Update (5 min)



Activity (30 min)



Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 6 or Engineering Journal, p. 17
- ☐ *Engineering Design Process* poster
- ☐ Scrap Market materials

For each group of 3-5 kids:

- ☐ Recycled Racer from Adventure 3
- ☐ tape
- ☐ scissors

For each kid:

- ☐ Engineering Journal

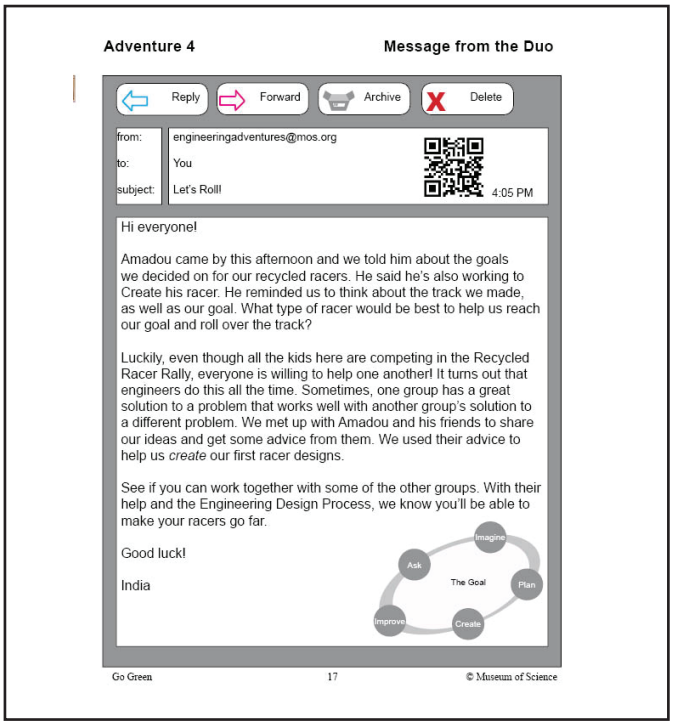
Preparation

Time Required: 5 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Set out the Scrap Market bins with materials.
4. Read the "Notes on Troubleshooting" section, found on p. 36 of this guide.
5. Please note there is no track or ramp set up for this adventure.

Journal Pages for Adventure 4

Message from the Duo, p. 17



Adventure 4 **Message from the Duo**

Reply | Forward | Archive | Delete

from: engineeringadventures@mos.org
to: You
subject: Let's Roll!
4:05 PM

Hi everyone!

Amadou came by this afternoon and we told him about the goals we decided on for our recycled racers. He said he's also working to Create his racer. He reminded us to think about the track we made, as well as our goal. What type of racer would be best to help us reach our goal and roll over the track?

Luckily, even though all the kids here are competing in the Recycled Racer Rally, everyone is willing to help one another! It turns out that engineers do this all the time. Sometimes, one group has a great solution to a problem that works well with another group's solution to a different problem. We met up with Amadou and his friends to share our ideas and get some advice from them. We used their advice to help us *create* our first racer designs.

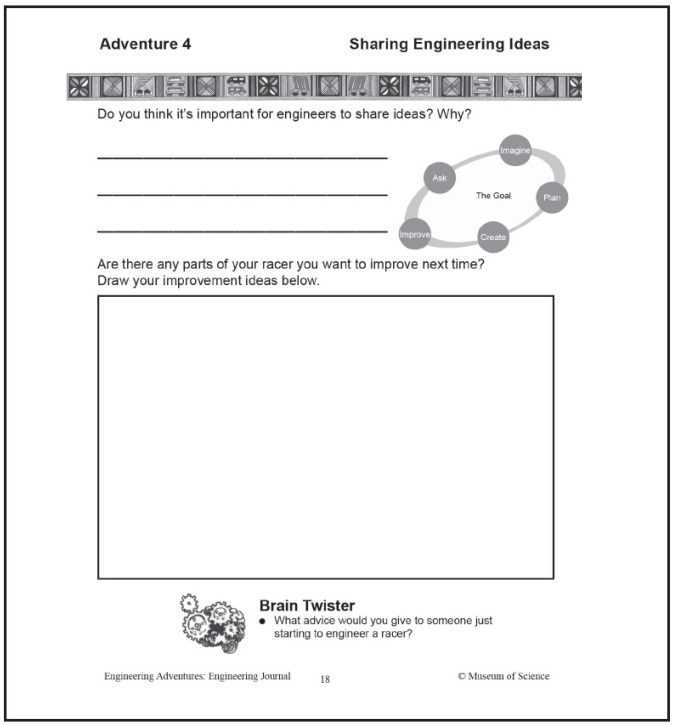
See if you can work together with some of the other groups. With their help and the Engineering Design Process, we know you'll be able to make your racers go far.

Good luck!

India

Go Green 17 © Museum of Science

Sharing Engineering Ideas, p. 18



Adventure 4 **Sharing Engineering Ideas**

Do you think it's important for engineers to share ideas? Why?

_____

_____

_____

Are there any parts of your racer you want to improve next time? Draw your improvement ideas below.

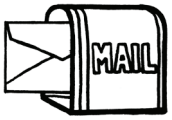
Brain Twister

- What advice would you give to someone just starting to engineer a racer?

Engineering Adventures: Engineering Journal 18 © Museum of Science

Creating a Recycled Racer

Kids will learn:
- they can apply their knowledge of wheels and axles to their racer.
- engineers can benefit from sharing ideas.

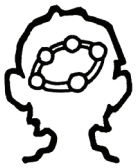


Present the Message From the Duo (5 min)

1. Tell kids that India has some news about using teamwork to prepare for the Recycled Racer Rally.
2. Have kids turn to *Message from the Duo*, p. 17 in their Engineering Journals, to follow along. Play track 6.
3. To check for understanding, ask:
   - **What did India say the kids in Senegal were doing to *create* their recycled racers?** *They were working together to find solutions to their problems.*
4. Remind kids that they shared findings and ideas with each other at the end of the last adventure. They should continue giving suggestions to other groups as they work today.

Plan and Create: Try it Out! (30 min)

1. Tell kids they will now have time to work on their recycled racers. Some groups may start from scratch, others may build off of previous experiments. Many groups will likely need to troubleshoot their wheels. Remind them they can look at *Wheel and Axle Templates*, pp. 10-11 in their Engineering Journals, use the steps of the Engineering Design Process, and advice from other groups to help them.
2. Remind groups they should keep their stated Recycled Racer goal in mind as they design. Today, they should test their racers on the ground and really focus in on how well their racer rolls and meets their chosen goal. In the next adventure, they will be able to do final tests using the ramp and track.
3. As kids work, ask questions like:
   - **What is working well for your racer?**
   - **What still needs to be *improved*?**
4. After kids have had a chance to work on their racers, have them return materials they did not use to the correct bin in the Scrap Market.



Reflect (10 min)

1. Tell kids that they will have an opportunity to continue *improving* and testing their racers on the track in the next adventure.
2. Collect all of the racers and set them aside to be used in the next adventure.
3. Gather kids together and show them the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process were the most**

helpful to you today? *Accept all answers, but encourage kids to think about how they* planned, created, *and* improved.

- **Did you use any ideas from other groups or other racers?**

4. Congratulate kids on using the Engineering Design Process and sharing their engineering ideas.
5. Give kids time to record thoughts on *Sharing Engineering Ideas*, p. 18 in their Engineering Journals. Having kids record their ideas will help them remember what they learned and apply it in the next adventure.

Notes on Troubleshooting

While each group of kids and each racer design is unique, testing of this unit has revealed some common difficulties you might look out for as kids work:

1. The wheels are wobbly: Wobbly wheels are usually caused by the axle not fitting tightly into the hole or connection point in the wheel material. This can often be fixed by:
   - increasing the thickness of the axle by wrapping it with another material, such as tape or paper.
   - using "shims" to increase the thickness of the axle. This can be done by sticking small pieces of other materials, like a piece of straw, coffee stirrer, or pipe cleaner, through the hole in the center of a wheel material.
2. The wheels are not touching the ground: Sometimes kids run the axle through the middle of their car bodies. For big wheels this may be fine, but for smaller wheels this will prevent the wheels from making contact with the ground. This can often be fixed by:
   - running the axle through the lower portion of the racer body, or creating a housing on the bottom of the racer that will hold the wheel and axle.
   - using larger wheels.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
subject:	You
to:	Let's Roll!

4:05 PM

Hi everyone!

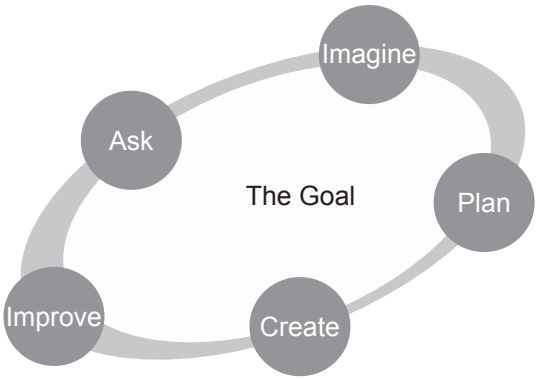
Amadou came by this afternoon and we told him about the goals we decided on for our recycled racers. He said he's also working to *create* his racer. He reminded us to think about the track we made, as well as our goal. What type of racer would be best to help us reach our goal and roll over the track?

Luckily, even though all the kids here are competing in the Recycled Racer Rally, everyone is willing to help one another! It turns out that engineers do this all the time. Sometimes, one group has a great solution to a problem that works well with another group's solution to a different problem. We met up with Amadou and his friends to share our ideas and get some advice from them. We used their advice to help us *create* our first racer designs.

See if you can work together with some of the other groups. With their help and the Engineering Design Process, we know you'll be able to make your racers go far.

Good luck!

India

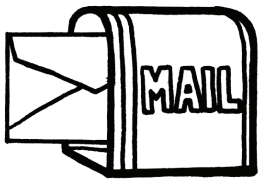


Overview: This optional adventure gives kids the chance to experiment with ways to use air power to move their racers.

Note to Educator: The track is not used in this adventure. Groups will focus on powering their racers with air and will test on the track in Adventure 5.

Be sure to save the recycled racers kids design for Adventures 5 and 6.

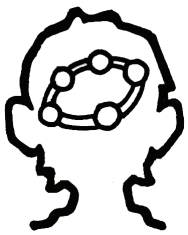
Duo Update (5 min)



Ask (5 min)

Activity (25 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 7 or Engineering Journal, p. 19
- ☐ *Engineering Design Process* poster
- ☐ 10 grocery bags
- ☐ 30 construction paper sheets
- ☐ 50 index cards, 5” x 8”
- ☐ Scrap Market materials

For each group of 3-5 kids:

- ☐ Recycled Racer from Adventure 4
- ☐ toy car
- ☐ tape
- ☐ scissors

For each kid:

- ☐ Engineering Journal

Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Set out the Scrap Market bins with materials.
4. Please note there is no track or ramp set up for this adventure.

Journal Pages for Adventure 4a

Message from the Duo, p. 19

Adventure 4 **Message from the Duo**

Reply | Forward | Archive | Delete

from: engineeringadventures@mos.org
to: You
subject: Let's Roll!
4:05 PM

Hi everyone!

Amadou came by this afternoon and we told him about the goals we decided on for our recycled racers. He said he's also working to Create his racer. He reminded us to think about the track we made, as well as our goal. What type of racer would be best to help us reach our goal and roll over the track?

Luckily, even though all the kids here are competing in the Recycled Racer Rally, everyone is willing to help one another! It turns out that engineers do this all the time. Sometimes, one group has a great solution to a problem that works well with another group's solution to a different problem. We met up with Amadou and his friends to share our ideas and get some advice from them. We used their advice to help us *create* our first racer designs.

See if you can work together with some of the other groups. With their help and the Engineering Design Process, we know you'll be able to make your racers go far.

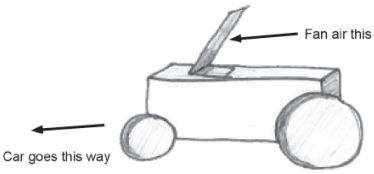
Good luck!

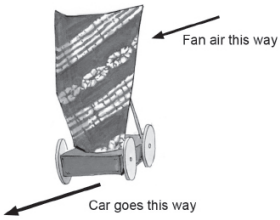
India

Air Powered Racers, p. 20

Adventure 4a (optional) **Air Powered Racers**

Here are two examples of cars powered by air!





My Air Powered Racer, p. 21

Adventure 4a (optional) **My Air Powered Racer**

Draw your final racer here and show how you will use air power to move it. Circle parts you want to improve.

For the Record

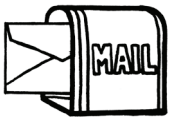
I think my racer is a technology. ☐ Yes ☐ No

Why? _____

_____

Air Power

Kids will learn:
- they can use air to move their recycled racers.



Present the Message From the Duo (5 min)

1. Tell kids that Jacob has some news about the way their racers will move on the race track during the Recycled Racer Rally. He sent a message to tell them more about it.
2. Have kids turn to Message from the Duo, p. 19 in their Engineering Journals, to follow along. Play track 7.
3. To check for understanding, ask:
   - **What is Jacob asking you to do?** *Use a sail and air to power our racers.*
   - **What ideas do you have for powering your racers with air?**

Ask: Sail Power (5 min)

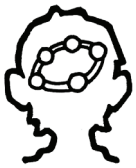
1. Tell kids you have an example from India and Jacob that is like the pictures on *Air Powered Racers*, p. 20 in their Engineering Journals.
2. Pass out a toy car (the same cars used in Adventure 1), two index cards, and tape to each group of 3-5 kids.
3. Have groups fold one index card in half and tape it to the top of the toy car. Have kids use the other index card as a fan to blow the toy car across the table. Ask:
   - **How could you use this idea to power your racer?** *We could attach a sail on top to catch the wind.*
4. Let kids know that along with index cards, India and Jacob sent along a few other materials that are often thrown out: scrap paper and plastic grocery bags. Kids can choose any of these to add a sail to their racer.

Plan and Create: Try it Out! (25 min)

1. Tell kids they can now use the *plan* and *create* steps to engineer a way to move their racers with air.
2. As kids work, encourage them to try new things. They might change the shape, size, or placement of their sail.
3. When groups test, ask:
   - **What is working well about your sail to power your racer?**
   - **What needs to be improved?**
4. After kids have had a chance to experiment with several different ways to move their racers, have kids return materials they did not use to the correct bin in the Scrap Market.

Tip: If groups do not yet have racers that roll well, powering them with air will be tough. Some groups may need to troubleshoot wheel issues before engineering sails.

Reflect (10 min)



1. Tell kids that they will have an opportunity to *improve* their designs and try them on the track in the next adventure.
2. Gather kids together and show them the *Engineering Design Process* poster.
3. Allow some groups to share their designs with everyone. Ask:
   - **How does your sail work?**
   - **Which steps of the Engineering Design Process were the most helpful to you today?**
4. Congratulate kids on using the Engineering Design Process and remind them they still have one more adventure to focus on the *improve* step.
5. Give kids time to record thoughts on *My Air Powered Racer*, p. 21 in their Engineering Journals. Having kids record their ideas will help them remember what they learned and things they might want to improve upon in the next adventure.
6. Add the sail materials to the Scrap Market for kids to use in the next adventure.

Tip: Encourage groups to make their racers as lightweight as possible if they are having trouble getting their racer to roll well with air power.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Air Power!

11:23 AM

Hi everyone!

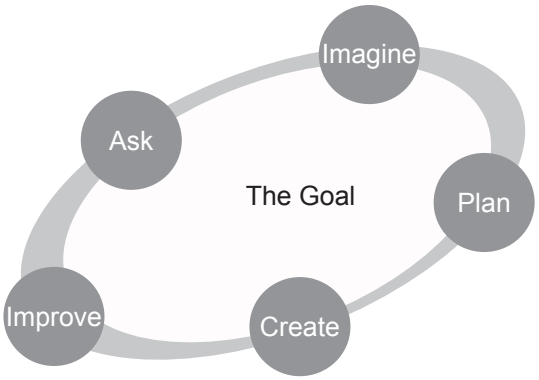
We love the work you've done on your racers! We have made a lot of progress engineering our racers, too.

Amadou had a great idea to make his racer even better. There are a lot of toy cars that use batteries to power them, but as a green engineer, Amadou wants to use something that is more friendly for the environment. Batteries are difficult to get rid of, and there are so many other options to make a racer go. He said that he's going to add a sail to his racer so he can use air to power it. India quickly began to strap all kinds of sail materials onto her racer, but I suggested that we test a few parts out on their own first. It would be a good use of the *imagine* and *plan* steps of the Engineering Design Process!

Can you *imagine* a way to use air to power your racer? Make a *plan*, attach a sail to your racer, and give it a go!

Jacob

P.S. We sent you a few materials to get you started.

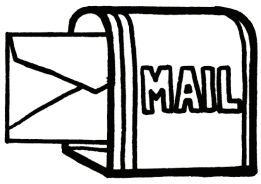


Improving a Recycled Racer

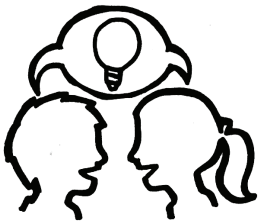
Overview: Kids will continue *improving* their recycled racers and kids who have extra time can decorate their racers and create a team race flag.

Note to Educator: While this adventure may seem repetitious, we have found that many groups need the additional time to work on wheels and get their racer to meet their stated goal. Groups that do not need much more time to engineer usually enjoy decorating their racers. **Be sure to save the recycled racers kids engineer for Adventures 6, the Engineering Showcase!**

Duo Update (5 min)

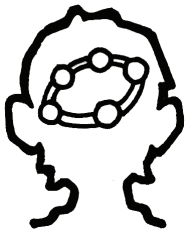


Set the Stage (5 min)



Activity (25 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 8 or Engineering Journal, p. 22
- ☐ *Engineering Design Process* poster
- ☐ ramp
- ☐ race track
- ☐ Scrap Market materials

For each group of 3-5 kids:

- ☐ Recycled Racer from Adventure 4
- ☐ tape
- ☐ scissors
- ☐ markers

For each kid:

- ☐ Engineering Journal

Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Set up the track and ramp.
4. Lay out the Scrap Market bins with materials.

Journal Pages for Adventure 5

Message from the Duo, p. 22

Adventure 5 **Message from the Duo**

Reply | Forward | Archive | Delete

From	engineeringadventures@mos.org
Subject	Let's go!
To	You

12:32 PM

Hey engineers!

Jacob, Amadou, and I are impressed with the work you've done engineering your racers. Now it's time to use the Improve step of the Engineering Design Process to make your racers the best they can be. Make sure to think about the goal for your racer as you make improvements.

The latest news from Amadou is that each team will be able to race their car twice. Your team should aim for a personal best out of the two races.

If you have extra time, decorate your car before the Recycled Racer Rally! I want to use some scrap paper and markers I found to decorate our racer. We are green engineers, after all. While we were at the Scrap Market with Amadou, he showed us some great Senegalese fabrics. I sent you pictures so you could see, too. We're going to use ideas from these patterns to decorate our car. As a surprise for Jacob, I'm also making us a team flag to wave during the Recycled Racer Rally.

The Recycled Racer Rally is just around the corner! Let's Improve our racers and decorate them so they're ready to roll!

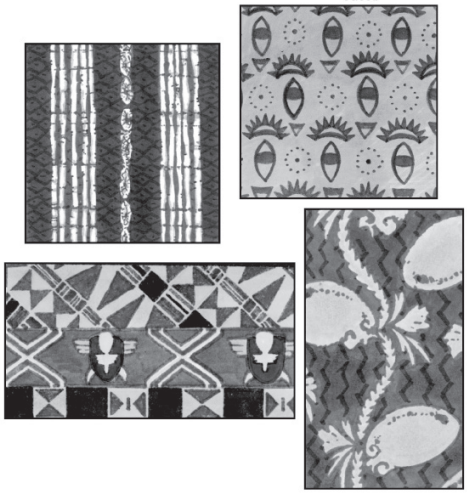
India

Patterns of Senegal, p. 23

Adventure 5 **Patterns of Senegal**

Hello!
Here are some pictures of the fabrics I saw at the Scrap Market. I'm going to use the patterns to help decorate our Recycled Racer!

-Jacob



Improve, p. 24

Adventure 5 **Improve**

The goal of our racer is:

Draw the final version of your recycled racer below.

Which step of the Engineering Design Process helped you most today? Write what you did for that step.

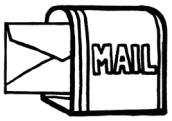
_____

_____

_____

Improving a Recycled Racer

Kids will learn:
- they can use the Engineering Design Process to find a successful solution.
- even designs that are working well can be *improved*.
- designs do not always work the first time; they can learn from their failures.



Present the Message from the Duo (5 min)

1. Tell kids that today they will continue *creating* and *improving* their racers so they are ready for the Recycled Racer Rally. Jacob sent a message to give them some details.
2. Have kids turn to Message from the Duo, p. 22 in their Engineering Journals, to follow along. Play track 7.
3. To check for understanding, ask:
   - **What is Jacob asking you to do?** Improve *our racers so they will be ready to test two times in the Recycled Racer Rally. Decorate them and make a team flag if we have enough time.*

Set the Stage (5 min)

1. Have kids gather in their groups with their recycled racers. Have a few groups share their current racer designs with the rest of the group.
2. As groups present, ask:
   - **What is the goal you chose for your racer?**
   - **What will you do today to *improve* your design?**
3. Tell kids not to worry if their first designs were not successful or they are still struggling. Failure is an important part of the Engineering Design Process. The *improve* step gives them a chance to try new things.
4. Let kids know the ramp and track will be available for them to test with today.
5. Show kids the Senegalese fabric designs on *Patterns of Senegal*, p. 23 of their Engineering Journals (also in this guide, p. 51). Let them know they can use the patterns as inspiration, or choose to decorate their racers using their own designs.

Tip: Be sure kids know this session will be the last time they have to work on their racers before presenting them. Their top priority should be engineering a racer to meet their stated goal, and decorating should be done only after that!

Plan and Improve (25 min)

1. Have kids gather in their groups and begin *improving* or decorating their racers. They can test on the track whenever they are ready.
2. Encourage kids to work together and test their designs on the track as they go along. Remind kids they will have two chances to test at the Recycled Racer Rally, and they will focus on trying to beat their personal best.
3. As groups test, ask:

- **How are your improvements helping your racer meet your goal?**

Reflect (10 min)

1. Have kids return any materials that can still be used to the correct bins at the Scrap Market.
2. Collect each group's recycled racer design for use in the next adventure.
3. Show kids the *Engineering Design Process* poster. Ask:
   - **How did you use the Engineering Design Process to *improve* your recycled racer designs?** *We used the* improve *step because we made our designs better. We also used the* plan *step to decide what our improvements would be and the* ask *step when we asked what improvements we wanted to make.*
   - **Do you think engineers need to *improve* their designs?** *Yes, engineers* improve *their designs many times before they are done.*
4. Tell kids they will be racing their designs in the Recycled Racer Rally during the next adventure. They will share how they used the Engineering Design Process to create their vehicles.
5. Give kids time to record what step of the Engineering Design Process helped them most today on *Improve*, p. 24 in their Engineering Journals. Having kids think about how they used the Engineering Design Process today will help prepare them to talk about it at the Recycled Racer Rally.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Almost Ready to Roll

12:32 AM

Hey engineers!

India, Amadou, and I are impressed with the work you've done engineering your racers. Now, it's time to use the *improve* step of the Engineering Design Process to make your racers the best they can be. Make sure to think about the goal for your racer as you make improvements.

The latest news from Amadou is that each team will be able to race their car twice. Your team should aim for a personal best out of the two races.

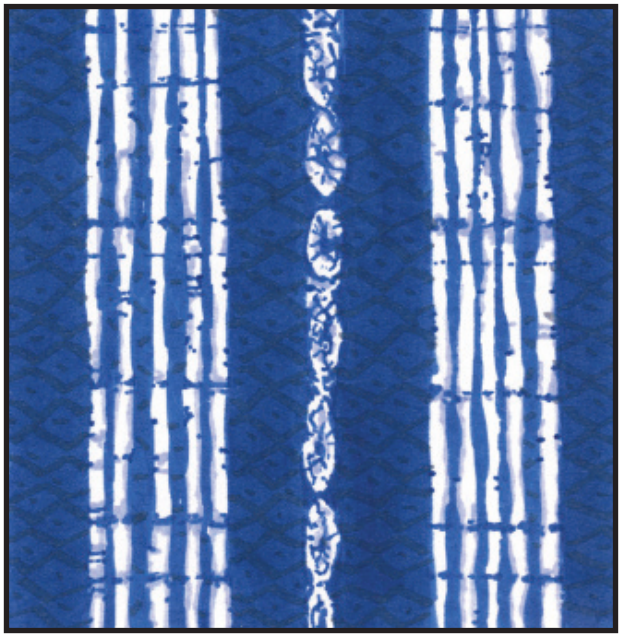
If you have extra time, decorate your car before the Recycled Racer Rally! I want to use some scrap paper and markers I found to decorate our racer. We are green engineers, after all. While we were at the Scrap Market with Amadou, he showed us some great Senegalese fabrics. I sent you pictures so you could see, too. We're going to use ideas from these patterns to decorate our car. As a surprise for India, I'm also making us a team flag to wave during the Recycled Racer Rally.

The Recycled Racer Rally is just around the corner! Let's *improve* our racers and decorate them so they're ready to roll!

Jacob

Hello!
Here are some pictures of the fabrics I saw at the Scrap Market. I'm going to use the patterns to help decorate our Recycled Racer!

-Jacob

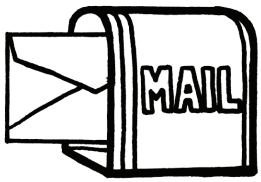


Engineering Showcase: Recycled Racer Rally!

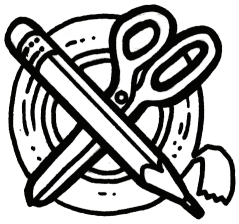
Overview: Kids will hold a showcase in which they present their final racer designs and participate in the Recycled Racer Rally.

Note to Educator: This is a time for your group to share all of their hard work with family and friends! Consider inviting guests to the engineering showcase, and encourage kids to share the specific challenges that their group worked on and overcame.

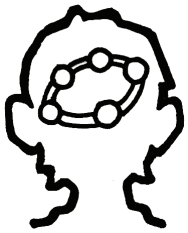
Duo Update (5 min)



Activity (30 min)



Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 9 or Engineering Journal, p. 25
- ☐ *Engineering Design Process* poster
- ☐ ramp
- ☐ race track
- ☐ Scrap Market materials

For each group of 3-5 kids:

- ☐ Finished Recycled Racers

For each kid:

- ☐ Engineering Journal
- ☐ markers (optional)

Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Set up the track and ramp.
4. Decide where you would like groups to present, and make sure the *Engineering Design Process* poster is visible from that spot.

Journal Pages for Adventure 6

Message from the Duo, p. 25

Adventure 6 **Message from the Duo**

Reply | Forward | Archive | Delete

from: engineeringadventures@mos.org
to: You
subject: Start Your Engines!
9:01 AM

Hi engineers!

It's time for the Recycled Racer Rally! Are you excited? We can't wait to hear how your racers do. Your goal is to test your racer two times to see how well it meets the goal you decided on for your racer!

Before the races begin, take some time to think about all of the engineering work you've done. You started with scraps, and now you have amazing racers! Can you believe that you engineered your racers out of things you'd normally just throw away? You have been fantastic green engineers.

A lot of people don't know about green engineering. They don't know that it's possible to engineer fun, useful things in ways that don't hurt the environment. Someone needs to tell them. And guess what? You are all experts now!

You can use the Recycled Racer Rally as an opportunity to teach people about the green engineering work you did and explain how you used the Engineering Design Process to help you.

Let us know how it goes!
India and Jacob
engineeringadventures@mos.org

Go Green 25 © Museum of Science

My Next Engineering Adventure, p. 26

Adventure 6 **My Next Engineering Adventure**

For the Record

I would like to be a green engineer. ☐ Yes ☐ No ☐ Maybe so

Why or why not?

What do you want to engineer next?

Draw your technology here!

My engineering checklist:

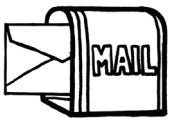
- ☐ Find friends to work with.
- ☐ **Ask** questions about how to start.
- ☐ **Imagine** lots of ideas.
- ☐ Make a **Plan**.
- ☐ **Create** and test the plan.
- ☐ **Improve** until you think it is ready.

What materials will you use?

Engineering Adventures: Engineering Journal 26 © Museum of Science

Engineering Showcase: Recycled Racer Rally!

Kids will learn:
- each team used the Engineering Design Process in its own way to engineer a recycled racer.
- everyone can engineer!



Present the Message from the Duo (5 min)

1. Tell kids that today they will show off their designs and send them down the track two times to see how well their racers meet their stated goal. Teams should be trying to achieve their personal best record! India and Jacob sent a message.
2. Have kids turn to *Message from the Duo*, p. 25 in their Engineering Journals, to follow along. Play track 9.
3. To check for understanding, ask:
   - **What are India and Jacob asking you to do?** *Compete in the Recycled Racer Rally and teach others about green engineering.*
   - **What is the goal of the rally?** *To get our personal best for meeting the recycled racer goal we chose.*

Recycled Racer Showcase (15 min)

1. Before the Rally, groups will show the racers they engineered. Have each group present their racers one at a time.
2. Encourage groups to use the *Engineering Design Process* poster to help them talk about how they used each step.
3. Ask groups questions like:
   - **How did you use the steps of the Engineering Design Process to engineer your racer?**
   - **How does the design of your racer help you meet your goal?**
   - **What part did you have to *improve* the most?**

Recycled Racer Rally (15 min)

1. Tell kids that they will have two tries to go down the track. They should keep track of both tries to identify their personal best race. For example, if their goal is to carry weight, they should count how many weights their racer carries on trial one, and test with more weight during trial two. If their goal is to go far, they might mark the distance their car travels during trial one, and compare it to trial two.
2. Have the first group share the goal of their racer. They should then send their racer down the track two times. After they are done, ask:
   - **Which trial was your personal best?**
   - **How well did your racer meet your goal?**
3. Repeat this process with each group.

Reflect (10 min)

1. After the Rally, gather kids together and ask:
   - **What was challenging about using these recycled materials?**
   - **What was fun about using these materials?**
   - **Do you think green engineering is important?** *Yes, so we can make fun, useful things in ways that do not hurt the environment.*
2. Show kids the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process helped you most?**
   - **Do you think you will use this process again?**
3. Congratulate kids on the engineering work they did. Remind them that several weeks ago, the group had no racers and just a pile of materials that would normally be recycled or thrown out. Today, they have unique recycled racers thanks to green engineering and their engineering skills.
4. Have kids fill out *My Next Engineering Adventure,* p. 26 in their Engineering Journals. Having kids think about what they might engineer next reinforces that they are successful engineers and can use the Engineering Design Process to solve many other problems!

Engineering Showcase: Recycled Racer Rally!

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Start Your Engines!

9:01 AM

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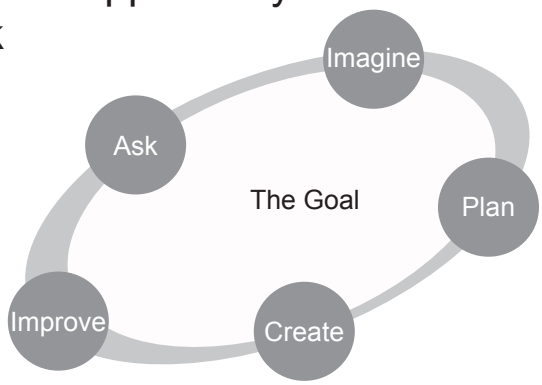

Let us know how it goes!
India and Jacob
engineeringadventures@mos.org

