



ThrillBuilders

Launch Your Own Crazy
Carnival of Moving Parts





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Our partnership with Girl Scout councils embodies the best in collaboration. We have shared resources and learned so much from teaming up on this project. Together we worked to inspire girls to change the world through engineering and science.



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About Techbridge

“Boring, nerdy, and only for boys.” Some girls may think of engineering in those terms, but not the girls participating in Techbridge. They say, “I learned that this science thing is very fun and educational at the same time. I LOVE IT!” and “I learned that engineering is not just for men.”

Techbridge is a leader in providing girls with firsthand experience working as engineers—from designing toys and building turbines, to meeting professional engineers who help make the world a better place.

Techbridge brings together best practices and lessons learned for partners and offers curriculum that builds on girls’ interests and expands their career options. We have seen first-hand the impact that role model visits and field trips can have. We offer training and resources to youth-serving adults to create positive experiences for girls.

The Techbridge program reaches out to girls in under-served communities and offers after-school and summer programs with hands-on projects and career exploration. Techbridge has served over 3,000 girls in elementary, middle, and high schools in Oakland, California and surrounding communities since its start in 2000. The program has been shown to increase girls’ confidence, build skills, and promote interest in careers in engineering, science, and technology.

In order to bring a Techbridge experience to girls across the country, we are partnering with Girl Scout councils. The Techbridge team has developed programs-in-a-box that include all the activities and materials you will need to introduce girls to the wonders of engineering and science. The Girls Go Techbridge program-in-a-box includes the leader guide you have in your hands, and the box of materials in front of you, ready for a group of ten girls to dive in and enjoy.

We invite you to partner with us to bring engineering and science to girls in your community. Together we can inspire a girl to change the world.

For more information, visit www.techbridgegirls.org.

ThrillBuilders: Suggested Schedule

Time	Session 1	Session 2	Session 3	Session 4
:00	Pre-Surveys (if applicable)	Career Activity: Illustrate Your Career	Icebreaker: Gearing Up!	Icebreaker: Fling It!
:10	Icebreaker: Simple Machines Scavenger Hunt		Activity: Merry-Go-Round	
:20				
:30				
:40	Activity: Mini Playground	Coaster Car	Career Activity: Park Plan	Activity: Bean Bag Toss
:50				
1:00				
1:10				
1:20				
1:30			Career Activity: Your Career Card	Career Activity: Career Catcher
1:40				Post-Surveys

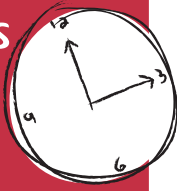
ThrillBuilders: Alternative Schedules

	6.5 Hours	4.5 Hours
:00	Icebreaker: Simple Machines Scavenger Hunt	Icebreaker: Simple Machines Scavenger Hunt
:10		
:20		
:30	Activity: Mini Playground	Activity: Mini Playground
:40		
:50		
1:00		
1:10		
1:20		Icebreaker: Gearing Up!
1:30	Activity: Coaster Car	Activity: Merry-Go-Round
1:40		
1:50		
2:00		
2:10		
2:20		
2:30	Icebreaker: Gearing Up!	Career Activity: Illustrate Your Career
2:40	Lunch	
2:50		
3:00		Icebreaker: Fling It!
3:10	Activity: Merry-Go-Round	Activity: Bean Bag Toss
3:20		
3:30		
3:40		
3:50		
4:00		
4:10		
4:20		Activity: Career Catcher
4:30	Career Activity: Illustrate Your Career	
4:40		
4:50	Icebreaker: Fling It!	
5:00	Activity: Bean Bag Toss	
5:10		
5:20		
5:30		
5:40		
5:50		
6:00		
6:10		
6:20	Career Activity: Your Career Card	
6:30	Activity: Career Catcher	

ThrillBuilders: Introduction

4 Suggested Sessions

approximately 1 hour and 30 minutes each



Skills:

- Designing projects with simple machines

Many of the products and places girls come into contact with every day have moving parts. Girls may not realize that so many of these machines were designed by **Mechanical Engineers**. This unit uses a fun, exciting place—an amusement park—as a basis for understanding simple machines and how they relate to things we use every day.

The ThrillBuilders program-in-a-box introduces girls to simple machines. Girls build simple machines in the form of amusement park

attractions. Girls will explore energy sources, mechanics, and design as they build their very own attractions for the amusement park. The career theme of this program is **Mechanical Engineering**, and a **Mechanical Engineer** can be introduced each session. An additional engineer is introduced in each activity as a complement to the wide range of projects **Mechanical Engineers** might work on. Some activities include:

☀ Mini Playground:

Girls will work as **Structural Engineers** and build playground equipment that contains at least three simple machines.

☀ Coaster Car:

Girls will take on the role of **Transportation Engineers** and design a car for a roller coaster that can travel under the power of gravity.

☀ Merry-Go-Round:

Girls will build a merry-go-round using bevel gears. As **Industrial Engineers**, they will determine the most efficient ways to run the ride.

☀ Bean Bag Toss:

Girls will use levers, fulcrums, and potential energy to create a catapult-inspired bean bag toss. They will judge the safety of the equipment as **Safety Engineers**.

Each activity includes an icebreaker that introduces key concepts. Be sure to do the icebreakers—*Simple Machine Scavenger Hunt*, *Gearing Up!*, and *Fling It!*—before continuing to the longer activities.

We encourage you to invite role models into your program and to take the girls on field trips. Our career cards include profiles of women in those fields, but nothing compares to a field trip to see where these engineers work. See page eleven for tips on planning a role model visit or field trip.

Recommendations:

Emphasize to the girls that many of the products we use every day have moving parts, and were designed by the types of engineers girls will meet during this unit.



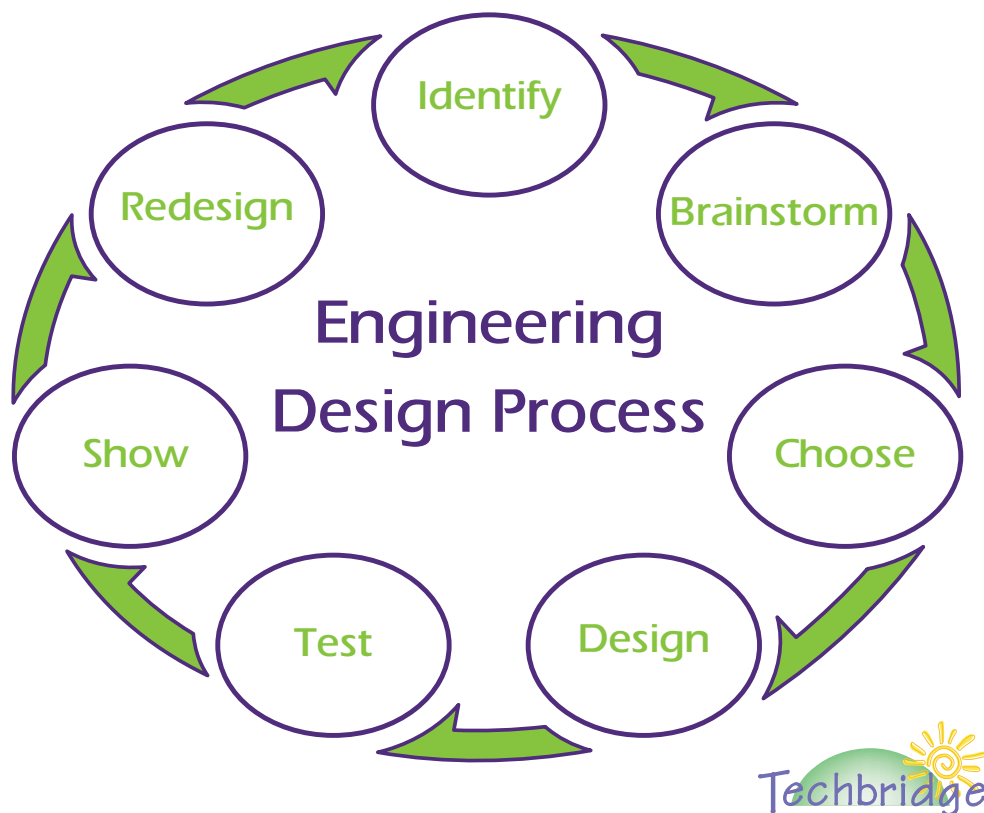
ThrillBuilders: Introduction

Engineering Design Process

The Techbridge **Engineering Design Process** is a never-ending cycle of creativity. With each of the hands-on activities in this guide, we encourage you to lead girls to identify and talk about where they are in the design cycle. Growing awareness of the design process helps girls strengthen their outcomes, whether it be a hand-made product or a presentation in front of a group.

The design process encourages girls to both “try, try again” and recognize that “two heads are better than one.” Engineers, and everyone from kids to professionals, use these steps to reach their desired result. We knew this was an effective tool when one Girl Scout remarked that she used the **Engineering Design Process** when writing and revising a paper for English class, and to persuade her parents to get a later curfew!

As the leader, you’ll have to know when it’s time to stop, but the more opportunities you allow girls to reflect, redesign, and repeat the design process steps, the better the experience for all. We recommend you display the supplied **Engineering Design Process** poster throughout these activities for easy reference.



Girl Scout Leadership Experience

In 2008, Girl Scouts of the USA introduced fifteen Leadership Outcomes to help leaders create and recognize a successful Girl Scouting experience. You know your girls are enjoying a quality Girl Scout activity when an out-of-school experience is **girl-led, experiential, and cooperative**. You see that your girls are leaders when they:

Discover...

- Girls develop a strong sense of self
- Girls develop positive values
- Girls gain practical life skills
- Girls seek challenges in the world
- Girls develop critical thinking

Connect...

- Girls develop healthy relationships
- Girls promote cooperation and team building
- Girls can resolve conflicts
- Girls advance diversity in a multicultural world
- Girls feel connected to their communities, locally and globally

Take Action...

- Girls can identify community needs
- Girls are resourceful problem solvers
- Girls advocate for themselves and others, locally and globally
- Girls educate and inspire others to act
- Girls feel empowered to make a difference in the world

We are proud that Techbridge's hands-on activities meet many of the Girl Scout Leadership Experience (GSLE) outcomes. Girls **gain practical life skills and develop critical thinking** abilities as they work through design challenges in our programs-in-a-box. By testing and redesigning their products, working through the **Engineering Design Process**, girls thrive on **challenges**, conquer doubts, and gain confidence and new perspective.

Girls **develop healthy relationships, learn to cooperate, and resolve conflicts** as they share, brainstorm, and negotiate in teams and pairs during Girls Go Techbridge activities. To build connectedness with your community, we encourage you to invite role models in engineering to interact with your girls. Remind your guest engineers to share that they are members of the very same community as your girls, and that together we can all be problem-solvers for the issues facing our world.

We hope, through the reflection and active questioning built into the Girls Go Techbridge activities, you will lead your girls to **identify community needs, educate and inspire others, and feel empowered** to make a difference in the world. While our hands-on-activities are presented in the context of having fun in an informal learning environment, there are real-world applications. With the skills and concepts learned by working through this program-in-a-box, girls gain the tools to make the world a better place.

Our mission at Techbridge is to **inspire a girl to change the world**. Thank you for sparking the fire for change.

Leader Tips

Tips on Grouping

Throughout the Activities and Icebreakers girls are often asked to work in groups. Below are a few tips to help you get started.

- Before breaking the girls into groups, consider having the girls brainstorm rules or norms for their behavior. They can refer to the Girl Scout Promise and Laws for ideas.
- Consider the relationships between the girls. How well do they know each other? Do they get along? Are some more familiar with the material or topic? This will help you create groups that are well balanced.
- Groups or teams larger than four can present problems for participation and interaction. Suggested group sizes are noted with each activity.
- To give everyone the opportunity to participate, consider assigning roles to each girl within the group. Possible roles include: group leader, reporter, recorder, set-up, clean-up, facilitator, manager. When assigning roles, make sure each girl is aware of the role's responsibilities. If possible across the activities, change it up so that girls are able to experience more than one role.
- Avoid rushing to rescue when a group is stuck, or providing "the answer." Let them discuss and come to their own conclusions. If you are talking, the girls have less time to talk and work together.
- Get involved when the group is hopelessly off task, when the group does not seem to understand enough to get started, when the group is experiencing serious personal conflict, or if the group can't organize themselves.
- To know if your groups are working, as you observe, check to see if the girls are: asking questions, listening to each other, helping each other, and explaining by telling how and why.

Tips on Facilitating Discussions

Discussions are an opportunity for girls to process and extend the different ideas they encounter throughout the activities. Below are a few tips to consider before beginning a discussion.

- Consider the physical set-up in your room. Can the girls see each other?
- Review and enforce the behavioral "norms" or rules established by the group.
- Listen well. Validate questions by either expanding on them or challenging them, and encourage girls to challenge each other in a productive and positive way.
- Allow for wait time when you ask a question. Give girls time to respond. To formulate thorough responses, they need time to process the question.
- Offer different options for participation. Letting girls turn in written responses often helps shy girls.
- Pause. Give the girls a few minutes to put together a response. Let girls discuss in small groups and then present their thoughts to everyone.
- Prompt girls with a variety of questions that require different levels of thinking.
 - * Some questions ask for basic knowledge and comprehension of the activity. For example, What differences exist between...? or Can you name the...?
 - * Some questions ask girls to apply or analyze the relationship between different ideas. For example, What factors would you change if...? or What are some of the problems of...?

Leader Tips

- * Some require girls to synthesize or evaluate concepts to new or different situations. For example, Can you see a possible solution to...? or How effective are...?
- To know if your discussions are working, check to see if the girls are asking for others' opinions, listening, thinking or reflecting on what has been said, giving reasons for their responses, and allowing everyone to contribute.

Keeping Girls Engaged

Programs-in-a-box are designed to be girl centered. Keeping your activity on track **and** the girls engaged is critical to the success of the activity and will help with learning, retention, and enthusiasm for the other activities. Down time during an activity can lead to girls getting off track. To keep girls engaged, try the following techniques:

- Mental warm up. In addition to using an icebreaker in the program, take a few moments to do a yoga move, a song, or group rhythm using clapping or stomping, etc.
- Know your girls! Who works well together? Who doesn't? Who will struggle with some of the content and who will approach it enthusiastically? Thinking about these different ideas for a few minutes before you begin can help you avoid problems getting started and keeping girls motivated. One of our goals is to promote cooperation and team building.
- Quietening girls down. Have the girls do a quick write, think-pair-share, journal, or draw for a minute. You could also use the Girl Scout tradition of raising your hand and standing silently to get attention. The next person does the same, and it continues until silence spreads throughout the group. The last person not paying attention is soon the only one talking.
- Know your activities. It is vital that you closely read over the activity. When you know what you have to do, there is little confusion and less down time for the girls.
- Ask three then me. This means that the girls ask three peers before coming to you for help. The result is that the girls are more likely to work through a particular problem on their own. They are the ones doing the work—make them accountable.
- Assign girls tasks. Let the girls read the introduction while you set up. Keeping the girls busy and involved in the task allows them to maintain interest and ownership in the activity.
- Heads up! When engaging hesitant or shy girls consider your grouping and let them know a little ahead of time that they will be asked to do something. We want to encourage participation through success!

Leader Tips

Tips on Brainstorming

Many girls are familiar with the brainstorming process, but have difficulty getting started or will want to move ahead with the first idea they think of. To encourage girls to generate as many ideas as they can, consider the following tips before you begin.

Begin with the T.E.C.H. guidelines for Brainstorming.

T – Think of many ideas. Write down all ideas, no matter how wild. The more ideas, the better!

E – Everyone’s ideas are good. Work as a team and respect every idea. Everyone should participate. Keep the tone positive!

C – Creativity. Be creative and spontaneous. There are no wrong answers and lots of possible solutions.

H – Have an open mind. Consider your own ideas and the ideas of others.

To get their brainstorming going:

- Use a visual. Have the girls examine the materials they’ll be using.
- Sketch. Suggest they do rough sketches.
- Think/pair/share. When brainstorming in pairs, have the girls think individually about the topic for a minute, pair with their partner to consider all ideas, and finally share with the group.
- Free writing. Some girls are more comfortable writing their ideas down in a list.
- Clustering/mapping/webbing. This technique focuses on the relationship between different characteristics or traits of the topic.
 - * Begin by writing the topic in the middle of a page. From the concept word, write as many related concepts or terms as you can associate with the central topic. If you run out of similar concepts, write down opposites, but try to keep writing and associating. As you jot down ideas, connect them with lines to show how they relate to each other.

TECH Brainstorming



T ➡ Think of many ideas

E ➡ Everyone’s ideas are good

C ➡ Creativity

H ➡ Have an open mind

Parent Resource Handout

This handout is designed to give parents some tips on how to support and encourage their daughters in science and engineering. Please send copies of this *Parent Resource Handout* home.

Encouraging Girls in Science and Engineering

You can make a difference in a girl's future! If you're looking for an activity to do with your daughter, try one that encourages the skills she would need to pursue science, technology, or engineering. Here are some ideas that build on the concepts explored in this program-in-a-box. Remind your daughter that almost every machine you see was designed in part by engineers, and particularly **Mechanical Engineers**.

1. Allow your child to tinker with tools around the house. Given permission, you will be surprised to see what she will come up with. Small appliances, like hair dryers, are safe to take apart once the power cord is cut off. See if you can figure out how the different parts work together.
2. Next time you visit a carnival or amusement park, check out the rides and see if you can figure out how they work. Are there levers, gears, or pulleys visible?
3. Get your daughter a kit to build. You can find mechanical animals and other kits that require following schematic drawings and using tools. Your daughter will gain confidence in building and learn how moving toys work.
4. Buy your daughter a set of K'NEX®. These building blocks allow for unlimited imagination when creating structures.
5. Next time you visit a playground, ask your daughter to point out the simple machines found in the equipment. Do the same in your kitchen, garage, or local construction site.
6. Check out a book about Rube Goldberg at your library, or look him up online. He was the inventor of interconnected machines now called Rube Goldberg machines. These machines perform simple tasks as a result of a chain reaction of events. The game Mouse Trap® is one example. Try building one yourself with recycled materials found around the house.
7. Next time you ride a plane or train, ask the conductor or attendant if you can take a peek into the cockpit or control booth. You might be surprised what they can tell you.
8. Sit and brainstorm with your daughter about how science and engineering is present in your home or environment.
9. Read Celeste Baines' *The Fantastical Engineer: A Thrillseeker's Guide to Careers in Theme Park Engineering*, available from www.engineeringedu.com.
10. Investigate Theme Park Engineering classes, workshops, and websites hosted by colleges around the country such as Ohio State, Penn State, Drexel University, and California State University at Long Beach.
11. Play with activities on www.pbskids.org/zoom/games or a free trial on www.brainpop.com/technology/simplemachines.



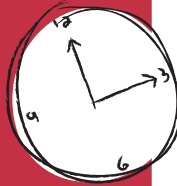
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Planning a Role Model Visit

Hands-on projects can spark an interest in science, technology, or engineering, but on their own they may not lead to a career interest in these fields. Role models can inspire girls and help them make informed decisions about their future. Interactions with role models require the right combination of career guidance and social engagement. The key is for role models to be personal and passionate while communicating how their work matters. A hands-on activity that offers a snapshot of their work will engage and inspire your girls.

Sample Schedule

10 minutes	Welcome and Icebreaker
10 minutes	Introduction by Role Model
55 minutes	Hands-on Activity
15 minutes	Wrap-up and Q&A



Suggested Activity:

Illustrate Your Career: The role model can lead this competitive and fun activity and talk about the journey along her own career path. The role model can draw things that symbolize her work and have the girls guess. The reflection questions in this activity would be good material for the role model to cover.

Finding role models:

- Contact your local Girl Scout Council's STEM coordinator for role model contacts. She may have contacts at organizations such as the Society of Women Engineers that can provide role models in your area.
- Ask your friends and contacts for leads.
- Check with science teachers who may have contacts.
- Is there an Expanding Your Horizons program in your community? You will find great role models at this event.
- Recruit role models from local businesses or universities.
- Recruit a diverse group of role models (especially individuals who reflect the diversity of your girls).
- Be creative!

Tips:

1. Share our role model resource guide ***Get Involved...Make a Difference*** and toolkit that includes suggested activities, questions, and other resources. <http://www.techbridgegirls.org/rolemodels.aspx>
2. Help your role model start with an icebreaker or a personal story to help them connect with your girls. We recommend using ***Put Yourself on the Line*** (from the online toolkit).
3. Invite role models to share their passion for what they do. When they get excited, your girls will too.
4. Encourage role models to explain why their work is important and how it helps the world.
5. Encourage role models to talk about more than just their job. Invite them to talk about hobbies, family, and friends which will help dispel stereotypes.
6. Role models can help by offering guidance such as the importance of taking advanced math and science classes, finding summer classes or internships, and getting good grades.
7. Make sure your girls send thank-you notes to role models after the visit.

ThrillBuilders: Materials

Sessions	Quantity	Consumable Materials	Non-Consumable Materials
1: Scavenger Hunt	10	Scavenger Hunt worksheets	
	10		Simple Machines reference sheets
	1		Simple Machine photo cards
	10		pencils
	1		pencil sharpener
1: Mini Playground	20	wooden skewers	
	20	spools/ straws	
	10	sheets of cardboard/ foam board	
	40	popside sticks	
	1	roll of string	
	20	foam sheets	
	20	wheels	
	10	glue sticks	
	1	roll of masking tape	
	10	paper plates	
	5		hot glue guns
	5		pencils
2: Illustrate Your Career	10	index cards	
	1		white board
	2		white board markers
	1		white board erasers
	2		sets of career cards
2: Coaster Car	10	sheets of cardboard/ foam board	
	20	straws	
	40	wheels	
	20	skewers	
	1	roll of duct tape	
	20	glue sticks	
	5		hot glue guns
	1		tape measure
	10		scissors
3: Gearing Up!	1		egg beater
	1		corkscrew
	1		bicycle bell
	1		can opener
	1		ice cream scoop

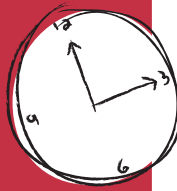
ThrillBuilders: Materials

Sessions	Quantity	Consumable Items	Non-Consumable Items
3: Merry-Go-Round	10	large cups	
	10	small cups	
	20	skewers	
	20	plastic bevel gears	
	10	paper plates	
	40	pipe cleaners	
	20	glue sticks	
	5	Merry-Go-Round handouts	
	5	Bevel Gear handouts	
	10	sheets of graph paper	
	10	Industrial Engineer: Park Plan sheets	
	10		pencils
	1		ruler
	1		pack of markers
	5		hot glue guns
	10		scissors
3: Your Career Card	10	blank career cards	
	10		pencils
	2		sets of 5 role model career cards
	2		boxes of permanent markers
4: Fling It!	10	wooden skewers	
	10	rubber bands	
	10	spools	
	10	plastic spoons	
	20	cotton balls	
	1	roll of masking tape	
4: Bean Bag Toss	200	popsicle sticks	
	30	cardboard squares	
	40	skewers	
	20	spools	
	50	rubber bands	
	50	glue sticks	
	5		hot glue guns
	10		Bean Bag Toss handouts
	10		mini bean bags
	10		scissors
4: Career Catcher	10	Career Catcher handouts	
	10		scissors

Simple Machines Scavenger Hunt

30 Minutes

+ 5 minutes preparation time



Materials:

Per Pair

- Simple Machines reference sheet
- Scavenger Hunt worksheet
- pencil

Optional

- 12 Simple Machine photo cards

Grouping: Pairs

Introduction: In this activity, girls will learn about different types of simple machines and will go on a scavenger hunt around the room or building looking for real-life examples.

Objectives: As a result of this activity, the girls will be able to:

- ☀ Identify six types of simple machines: inclined planes, wedges, screws, pulleys, wheels and axles, and levers.
- ☀ Describe how these machines work
- ☀ Give examples of each type of simple machine
- ☀ Recognize that a simple machine is part of any moving object

Science Behind It:

The six types of simple machines in this activity (inclined planes, wedges, screws, pulleys, wheels and axles, and levers) are used to make work easier by changing the amount or direction of a force required to do a task. When using a simple machine, you do the same amount of work, but less force is required so it seems easier. For example, when using an inclined plane, or ramp, to raise an object, you use less force to move it, but move the object a farther distance. This total amount of work (defined as force times distance) is the same as if you were to lift the object straight up (more force, shorter distance).

You can also change the direction of a force with a simple machine. With a pulley, you pull down to move an object up. With a screw, you use rotational, or twisting force, to drive the screw forward.

All machines with moving parts use at least one simple machine, and most use a combination of simple machines. For example, a bicycle uses wheels and axles, levers (on the brakes), and screws (for fastening). Gears are sometimes thought of as simple machines, but they are really a combination of a wheel and axle and a lever.

Preparation:

- **Familiarize** yourself with the six types of simple machines. Take a walk around your area to identify simple machines in your room or building so you are prepared with examples. If your area has few or no examples, plant the *Simple Machine* photo cards around the room for girls to discover.

Simple Machines Scavenger Hunt

Opening (3 minutes):

1. **Explain** to the girls that they will be going on a scavenger hunt today to learn more about simple machines. Ask the girls to volunteer any information they already know about simple machines.
 - Does anyone know what a simple machine is? Can you give some examples?
 - Where might you find a simple machine?

Brainstorm (5 minutes):

2. **Group** the girls into pairs to review the *Simple Machines* reference sheet, and challenge them to think of more examples for each machine. Examples might be a bicycle wheel for wheel and axle, or a door hinge for lever and fulcrum.

Hands-On (12 minutes):

3. **Distribute** the *Scavenger Hunt* worksheet. Have each pair identify the simple machines they see in the playground picture.
4. **Combine** two or more pairs together to discuss what machines they found in the picture, or share in a large group.
 - Where do you see simple machines in the playground?
 - Can you think of other playground equipment you have seen with this simple machine?
5. **Explore** in pairs. Send the girls around the room or building to look for more examples of simple machines. Each pair must find at least one example of each simple machine. Give them a time limit based on your schedule.

Recommendations:

There are online games related to simple machines, like this one on Rube Goldberg machines at:
<http://pbskids.org/zoom/games/goldburgertogo/rubegame.html>.



Simple Machines Scavenger Hunt

Reflection (10 minutes):

6. **Review** the examples the girls found. You might have a prize for most examples found, most creative finding, or most of a specific type of machine.
7. **Lead a discussion** using the following questions:
 - Were you surprised by where you found some of the simple machines?
 - Were there any objects that contained more than one simple machine? Did the machines work together or separately?
 - What do you think is the most useful simple machine? Why?
8. **Explain** that examining different kinds of machines to see how they work is one of the first steps in becoming a **Mechanical Engineer**. A **Mechanical Engineer** designs machines as a profession. Pass out the **Mechanical Engineer** career card for girls to read. Discuss what the girls find interesting or challenging about this profession.

Simple Machines Scavenger Hunt

Wheel and Axle



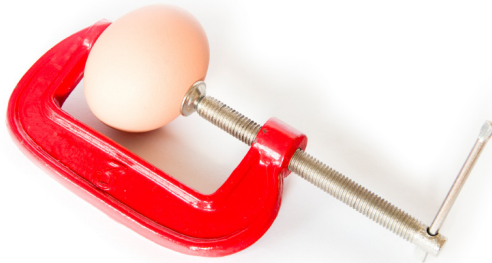
Screw



Wedge



Screw



Wedge



Lever (door hinge), Inclined Plane (doorstep), Wheel and Axle (bike), and Gears (bike)



Screw



Wedge (nail) and Lever (hammer claw)



Screws and Gears



Wedge



Pulley and Wheel and Axle



Inclined Plane (ramp) and Wheel and Axle (truck)



Simple Machines Scavenger Hunt

Key Terms

Simple machines are tools that make work easier. Simple machines work in two ways:

1. You exert less force, but move a greater distance.
2. You exert force in a different direction than the output force.

A **force** is something that pushes or pulls on an object.

A **fulcrum** is the supporting piece around which a lever moves.

A **lever** is a rigid object used with a fulcrum to make work easier. Just a small amount of force is needed on one end of a lever to make a larger force on the other end.

A **load** is a weight or mass supported by something.

Angle of rotation is the amount that something is moved around a fixed point. For example, the seat carts on a Ferris wheel move around the center point of the circle. If a cart was stuck at the top of the wheel, its angle of rotation is 180° . All the way around is 360° .

Simple Machines Reference Sheet

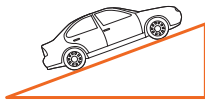
Simple Machines Reference Sheet

Types of Simple Machines

Simple machines are tools that make work easier. They have few or no moving parts.

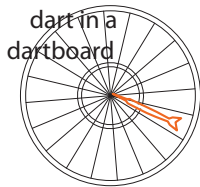
Inclined Planes, Wedges, Screws, and Pulleys

Inclined Planes



Description	Purpose	Examples
An inclined plane is a flat, slanted surface.	An inclined plane helps move objects up or down using less effort. If you push an object up a ramp instead of lifting it straight up, you are moving it a farther distance, but it requires less effort to move.	▪ wheelchair ramp ▪ slide

Wedges



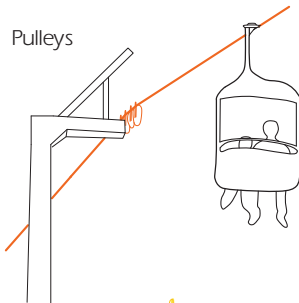
Description	Purpose	Examples
A wedge is two inclined planes pushed together to form a triangle. It can also be more round, like a cone.	A wedge is used to push two objects apart. When you exert force onto a wedge, it pushes outwards in two (or more) directions.	▪ door stop ▪ nail

Screws



Description	Purpose	Examples
A screw is an inclined plane wrapped around a cylinder-shaped object.	A screw usually fastens things together. You twist it into place, so you move it more than pushing it straight, but it is easier. You would need a large amount of force to pull it straight out.	▪ light bulb ▪ jar lid

Pulleys



Description	Purpose	Examples
A pulley is a rope that goes over a grooved circle.	A pulley simplifies lifting or lowering objects by changing the direction of force. You pull down to lift an object up. When you combine two or more pulleys, you can lift something very heavy.	▪ elevator ▪ clothesline



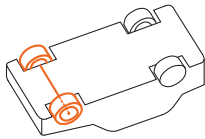
ThrillBuilders

Simple Machines Reference Sheet

Simple Machines Reference Sheet

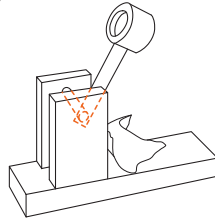
Wheels & Axles, Levers, and Gears

Wheels & Axles



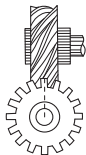
Description	Purpose	Examples
A wheel and axle are circular objects attached together. The wheel is the larger one, and there are usually two wheels attached to the same axle.	This makes moving an object easier because you can turn the axle a small amount, and the wheel rolls over a longer distance because it is larger.	- steering wheel - doorknob

Levers



Description	Purpose	Examples
A lever is a bar or board that pivots or moves at a fixed point called a fulcrum.	Levers are used to push against something heavy. By changing where the fulcrum is, you can lift something heavy. You can also move something in the opposite direction of the applied force. When you push down, you can move an object up.	- see-saw - hammer (claw side)

Gears*



Description	Purpose	Examples
Gears are wheels with interlocking teeth.	Gears fit together so that one wheel will turn the other. They work by changing the speed, direction, or angle of rotation or motion.	- clock - bicycle gear

*Note:

Gears are sometimes thought of as simple machines, but they are really a combination of a wheel and axle and a lever.

Scavenger Hunt Worksheet

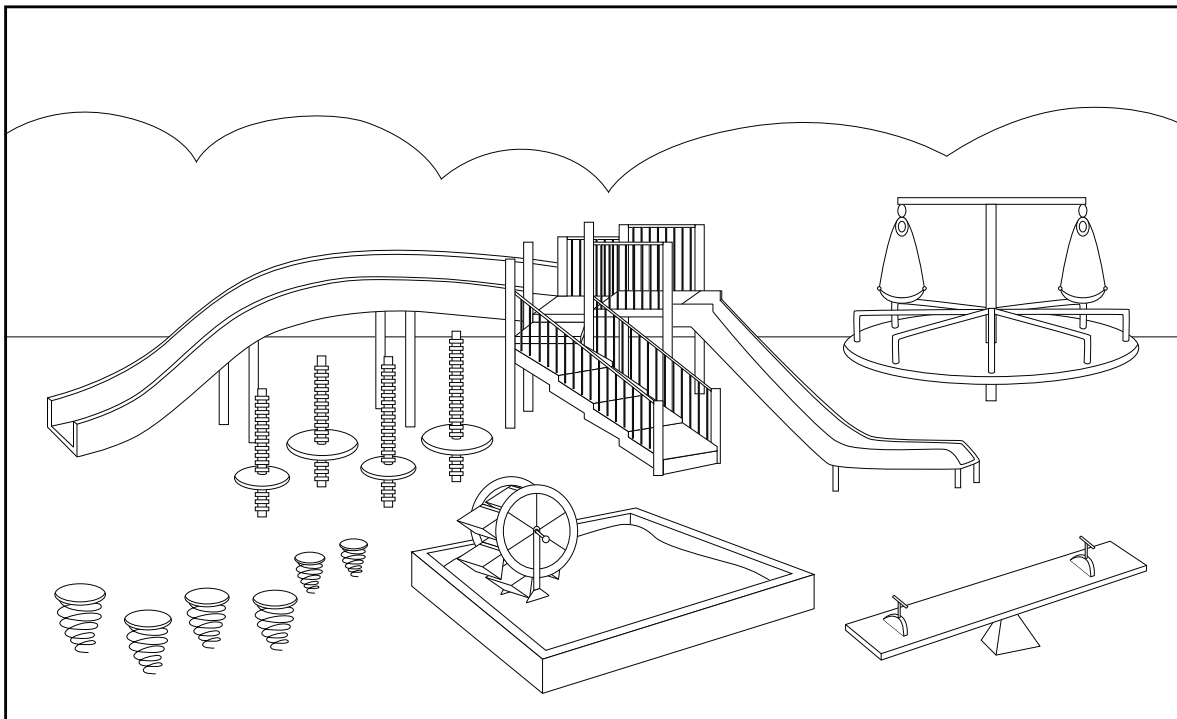
Scavenger Hunt Worksheet

Identify Simple Machines

This is an example of an imaginary playground with pieces of invented equipment that use simple machines. Look at the drawing. Can you identify the different simple machines used in the equipment? Remember that the six types of simple machines are inclined planes, wedges, screws, pulleys, wheels and axles, and levers.

Find at least one example of each type of simple machine. Circle and label the machines that you identified on the drawing.

Hint: Some pieces of equipment use more than one simple machine.



Scavenger Hunt Answer Key

Scavenger Hunt Answer Key

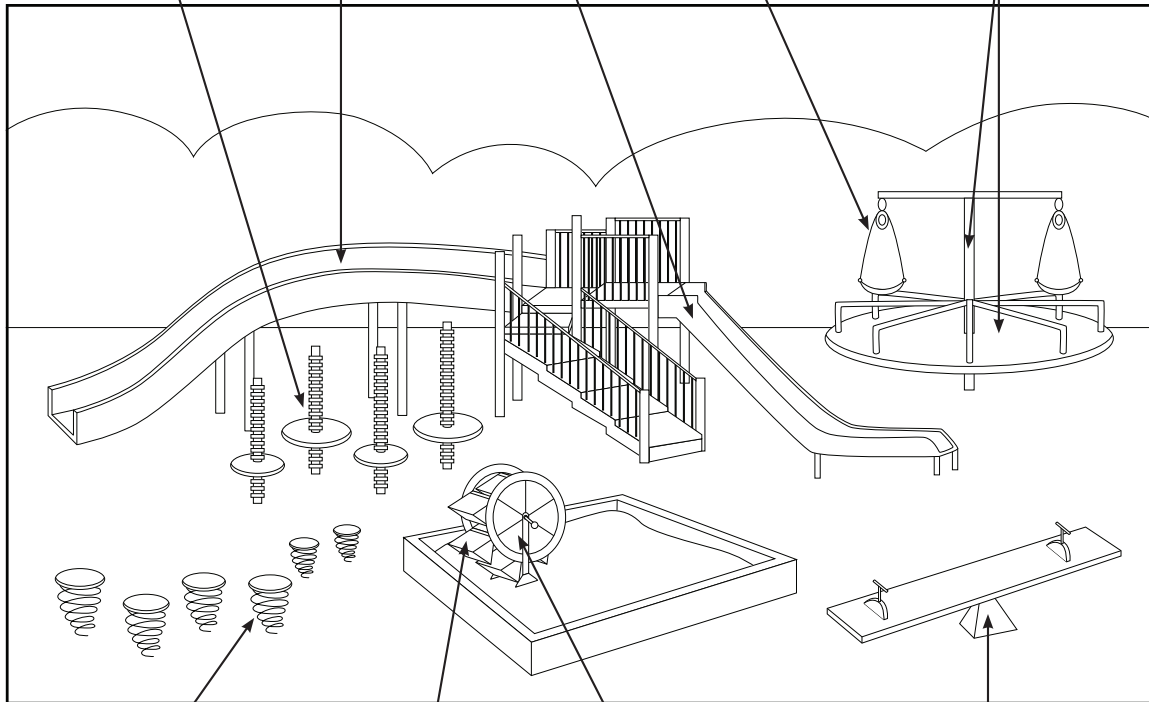
Screw: This piece of equipment is based on a washer and screw. Children can ride up and down by spinning the circular seat.

Pulley: This swing seat is attached to a pulley so it can be moved up and down.

Wheel & Axle: The wheel is the circular disk of the merry-go-round and the axle supports the swings at the top. The two are connected so when the merry-go-round spins, the swings rotate and vice versa.

Inclined Plane: Another example of a slide.

Inclined Plane: Children can slide down this flat slanted surface.



Screw: A screw is an inclined plane wrapped around a cylinder. Here, kids can bounce on springs.

Wedge: These shovel-like buckets scoop up sand as the wheels turn. They work as wedges by pushing the sand apart.

Wheel & Axle: Here, two wheels are attached to an axle. When the handle is cranked, the axle and wheels turn, and the buckets hung between the wheels rotate like cars on a Ferris wheel.

Lever: The see-saw is a board that pivots around a fixed point.

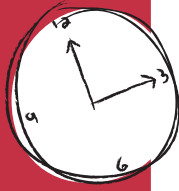
Techbridge

ThrillBuilders

Mini Playground

1 Hour

+ 10 minutes preparation time



Materials:

Per Pair

- spools
- popsicle sticks
- hot glue gun
- glue sticks
- string
- foam sheets
- cardboard
- wheels
- masking tape
- paper plate
- pencils
- scissors

Not Included

- scratch paper

Grouping: Pairs

Or individually if materials and time allow.

Introduction: In this activity, girls will use simple machines to design and build playground equipment.

Objectives: As a result of this activity, the girls will be able to:

- ✧ Work with and maximize limited resources
- ✧ Experiment with the uses of different simple machines
- ✧ Design a device including three types of simple machines
- ✧ Describe what **Mechanical and Structural Engineers** do

Science Behind It:

This project reinforces the simple machine concepts introduced in the *Simple Machine Scavenger Hunt* activity on page fourteen. Girls are introduced to two of the engineering careers included in this program-in-a-box.

Structural Engineers design structures that support loads, like buildings and bridges. They must retain the architect's design, but also follow safety regulations by making a bridge earthquake-proof or a school hurricane-proof.

Mechanical Engineers design and test all types of mechanical things. They are involved in a variety of projects, from consumer products like bikes and toys, to equipment like factory machines, to large scale projects like wind farms.

This is a good opportunity to emphasize the collaborative nature of engineering, and how engineers of different disciplines can work on one project.

Preparation:

- **Experiment** with the materials to find several ways of building the simple machines.
- **Arrange** the materials out so they are easily accessible and the girls see what they have to work with.

Mini Playground

Opening (8 minutes):

1. **Explain** to the girls that they will design and build a new piece of playground equipment that contains three or more simple machines. To do this, they will need to take on the roles of **Mechanical Engineers** and **Structural Engineers**.
2. **Distribute** the career cards and review them with the girls.
 - **Structural Engineers** design and build different types of structures. They need to figure out how to make them safe and functional.
 - **Mechanical Engineers** design different machines and moving parts.

Brainstorm (12 minutes):

3. **Consider.** As new playground designers, girls need to both make the equipment fun with moving parts, but make sure the design is safe and will stand up securely.
 - What other projects might a **Structural Engineer** or **Mechanical Engineer** work on?
4. **Describe** the different types of rides you might find in a playground or play area. For example, a slide is an inclined plane, a seesaw is a lever and fulcrum, and a rock wall might have a pulley system for safety. Consider the following questions:
 - What types of playground equipment can you think of?
 - Does it contain simple machines? Which ones?
 - What about more complicated pieces of equipment?
5. **Arrange** the girls into pairs and give each pair a pencil and piece of paper. Allow ten minutes to design a piece of equipment that includes at least three simple machines. Encourage the girls to be creative and design something no one has ever seen before.
6. **Ask** them to:
 - Think like a **Mechanical Engineer**: What simple machines are featured in your equipment?
 - Think like a **Structural Engineer**: How are you going to fit all those machines into one piece of equipment and make it stable?

Hands-On (30 minutes):

7. **Give** each pair a plate to build their equipment on. Using their initial designs, allow them thirty minutes to build their structures. Encourage girls to try different



Note:

The girls will be using glue guns. Stress that they get VERY hot and the glue can burn. Use craft sticks or other objects to press down the glue rather than your fingers to help prevent burns.

Mini Playground

configurations before gluing the pieces together.

8. **Consider** the following questions while circulating around the room:
 - How are you going to build that with the given materials? Is there a way you can modify it to work with what is available here?
9. **View.** Have a “gallery walk” where girls can see everyone’s completed structures and drawings. Share the playgrounds and have the designers identify the simple machines in them.

Reflection (10 minutes):

10. **Use** the following questions as a basis for discussing each design.
 - What challenges did you face working with limited resources? How is that similar to what a real engineer might face?
 - What simple machines are included in your design? Can you identify the different parts of the simple machines?
 - What parts of building this would the **Mechanical Engineer** be responsible for? What would the **Structural Engineer** be responsible for?
 - If you had a chance, what would you redesign in your equipment? How would you change or improve it?

Note:

To prepare for the **Illustrate Your Career** activity in Session 2, pull out the remaining career cards and give girls time to read. Ask for volunteers to stand up and “role play,” pretending they are the women on the cards and sharing the information on the cards.



Career Cards



Mechanical Engineer



Mechanical Engineers design and test different kinds of machines. Think of all the machines you use like appliances and automobiles. They are designed by **Mechanical Engineers** who find out what we need and how to make them so they're safe and functional.

As a **Mechanical Engineer**, you could design and build a bike that is easy to pedal up hills, machinery that makes toys, an aircraft carrier, a sailboat—anything that moves! The annual salary is \$80,580 which is about \$38 per hour.



Nancy Diaz
Master's in Mechanical
Engineering

Nancy's Biography:

When I was in middle school I wanted to be a surgeon. In high school, my favorite teacher suggested I try computer science. I decided I liked building things better, so I tried **Mechanical Engineering**. It was the perfect major for me because I got to design and work on hands-on projects.

As a Ph.D. student at the University of California Berkeley I build models of manufacturing equipment and test them on computers. Berkeley has an environmentally friendly manufacturing program, which I love.

How to do it:

To become a **Mechanical Engineer**, be sure to take advanced math or science classes like trigonometry and calculus. You'll learn statistics, strength of materials, design, and physics.

If you like learning about how things work, get your parent's permission and try taking apart things in your house like old hair dryers, coffee machines, or a lawn mower. Find information about your local engineering society and learn about opportunities like internships or camps.



Structural Engineer



Structural Engineers are responsible for designing structures that support large loads. They help design buildings and other large structures like bridges, dams, and parking structures, or large machinery like cranes. They make sure the design of the structure can hold up in an earthquake or hurricane, or that it will support heavy weights. **Structural Engineering** is usually considered a field within **Civil Engineering**.

Structural Engineers might design a building that sways in high winds, a bridge that withstands freezing temperatures or an oil rig that works in changing conditions. The annual salary is \$61,400, which is about \$29.50 per hour.



Kittrina McCourt
Degree in Civil Engineering
(focus on Structural Design)

Kittrina's Biography:

I wanted to be a chef when I was in middle school, but a teacher suggested I try engineering because I loved solving problems. I loved it, and picked **Structural Engineering** because I liked the idea of working with bridges. I also like drawing, and I have to draw all my designs so the city can approve them and the construction team knows what to build.

How to do it:

To become a **Structural Engineer** like Kittrina, be sure to take advanced math and science classes like trigonometry and physics at your school. Classes in design or drafting are helpful too.

In college, you will probably study **Civil Engineering** with a focus in structural design or engineering.

Illustrate Your Career

20 Minutes

+ 10 minutes preparation time



Materials:

Per team

- 1 set of role model career cards
- white board marker

Per Group

- white board
- eraser
- index cards

Grouping: 2 Teams

Introduction: In this activity, girls will learn about careers by playing a Pictionary-style game where they illustrate different careers.

Objectives: As a result of this activity, the girls will be able to:

- ✧ Describe six different science and engineering careers
- ✧ Give examples of what an engineer might work on

Preparation:

- **Read** the career cards to familiarize yourself with the careers described.
- **Create** five to ten additional careers of your choice on the index cards. They may be any type of career and do not have to be related to science

and engineering, although they can. For example, you might include teacher, doctor, writer, biologist, artist, etc.

Opening (2 minutes):

1. **Explain** that the girls are going to be playing a Pictionary-style game with careers. Ask if the girls are familiar with the game. Review the following rules:
 - Each team will designate one player to be the artist.
 - The leader will show the artists one card with a career on it.
 - The artists start drawing at the same time, and their team has to guess which career is being illustrated.
 - The artists may not talk or write any letters or numbers.
 - The first team to call out the full name of the career gets a point.
 - Tell the girls that the careers will include the six on the career cards and a few additional ones.
 - Begin a new round with new artists from each team.

Brainstorm (3 minutes):

2. **Group** the teams on opposite sides of the room. Pass out a set of career cards to each team and allow about ten minutes to read the cards.
3. **Draw.** Have the teams brainstorm images to represent each career on the career

Illustrate Your Career

cards. For example, they may draw a lever for **Mechanical Engineer** or a laptop for **Computer Scientist**. Be sure they have discussed each career on the cards before continuing.

- What stands out to you about this career? What object or picture might represent it?
- How will you remember that this picture represents this career?

Hands-On (10 minutes):

4. **Select** players from each team and begin the game according to the rules.
5. **Record** the score according to number of correct guesses, time taken to guess correctly, or creativity of drawings.

Reflection (5 minutes):

6. **Lead a discussion** using the following questions:
 - Were there careers that were similar? How did each team go about representing them in their drawings?
 - How do you think these careers would help in building an amusement park?
 - What else would someone in these careers work on?
 - What skills do you have that would make you a good fit for one of the careers?
 - Which career interests you the most? Why?

Note:

Salary information is from the National Bureau of Labor Statistics Occupational Employment and Wage Estimates as of May 2009.



Career Cards



Mechanical Engineer



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As a Ph.D. student at the University of California Berkeley I build models of manufacturing equipment and test them on computers. Berkeley has an environmentally friendly manufacturing program, which I love.

How to do it:

To become a **Mechanical Engineer**, be sure to take advanced math or science classes like trigonometry and calculus. You'll learn statistics, strength of materials, design, and physics.

If you like learning about how things work, get your parent's permission and try taking apart things in your house like old hair dryers, coffee machines, or a lawn mower. Find information about your local engineering society and learn about opportunities like internships or camps.



Industrial Engineer



Industrial Engineers work to make a process or product more efficient. They think about all of a company's resources - time, money, materials, and people - and how to make all these things work together in the best way possible. They might recommend doing tasks in a different order to save time, or how to use materials to reduce waste. They might set up a theme park so that people can move around without crowding, or oversee a construction project to coordinate efficient use of equipment and people. The annual salary is \$77,090 which is about \$37 per hour.



Jameka Johnson
Student, Master's in
Industrial Engineering

Jameka's Biography:

I found out early that engineering is not hard, but it requires hard work and dedication. At work, I help my team come up with solutions for different companies. I am never bored! Wherever I am, I look at the things around me and wonder why they are doing things that way. I get a buzz from figuring out how to make things better. I love that industrial engineering combines building with improving a product or process.

How to do it:

To become an **Industrial Engineer** like Jameka, take advanced math and science classes like calculus and physics. You should also try to take courses like economics or psychology.

Statistics and lab courses are useful because **Industrial Engineers** use these skills to compare different alternatives and measure results. As "better" means different things (easier, faster, cheaper, happier customers, higher quality), any business experience helps provide ideas.

Career Cards



Structural Engineer



Structural Engineers are responsible for designing structures that support large loads. They help design buildings and other large structures like bridges, dams, and parking structures, or large machinery like cranes. They make sure the design of the structure can hold up in an earthquake or hurricane, or that it will support heavy weights. **Structural Engineering** is usually considered a field within **Civil Engineering**.

Structural Engineers might design a building that sways in high winds, a bridge that withstands freezing temperatures or an oil rig that works in changing conditions. The annual salary is \$61,400, which is about \$29.50 per hour.



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How to do it:

To become a **Structural Engineer** like Kittrina, be sure to take advanced math and science classes like trigonometry and physics at your school. Classes in design or drafting are helpful too.

In college, you will probably study **Civil Engineering** with a focus in structural design or engineering.



Safety Engineer



Safety Engineers design and test different kinds of products, to make sure they are safe for the consumer. Imagine your daily life and all the products you use from toothpaste to seat belts. They are designed and tested by **Safety Engineers** who find out how best to make them so they're safe and work well.

As a **Safety Engineer**, there's no limit to the kinds of projects you might work on. For example, you could design a bicycle frame that withstands years of use and lots of bumps and abuse (not treating it nicely). The annual salary is \$91,670 which is about \$44 per hour.



Sarah Beth Hawkins
Master's in Civil Engineering

Sarah's Biography:

Have you ever heard of a magazine called *Consumer Reports*? This magazine tests and rates all kinds of consumer products, from cars to crackers. When my parents' copy of *Consumer Reports* arrived in the mailbox, I snatched it up and read it cover to cover. I was fascinated by their test labs. I wanted to use their shake tables, which mimic the movement of trucks, planes, and boats carrying cargo. Awesome!

How to do it:

To become a **Safety Engineer** like Sarah, be sure you take advanced science classes like physics and chemistry at your school. In college, take courses on steel, concrete and bridge design.

You should search out opportunities to work as a lab assistant to learn procedures, safety, and how to analyze results. If possible get a summer internship at a lab, testing the strength and durability (how long things last) of various products.

Career Cards



Transportation Engineer



Transportation Engineers are a type of **Civil Engineer**, and work to move people and things around safely and efficiently. You might combine geometry, math and psychology to understand your work.

As a **Transportation Engineer** you might compute how many cars can safely drive on the highway at the same time, and how they enter and exit the traffic lanes. You might plan and draw the entrances to a shopping mall parking lot, to prevent major traffic jams. The annual salary is \$51,391 which is about \$24.70 per hour.



Kayla Kelly
Degree in
Transportation and
Materials Engineering

Kayla's Biography:

In high school, I had no clue what I would study. I wanted to do everything from sports photography to racing horses as a jockey. I actually started college as an accounting major because I love math and I heard that engineering was hard.

I quickly learned that I hated accounting so I changed my major sophomore year to engineering and have never looked back. It goes to show that even if you are initially intimidated, that's no reason to stop pursuing what you're good at!

How to do it:

To become a **Transportation Engineer** like Kayla, be sure you take advanced math and physics.

Are you good at drawing maps, giving directions to get from here to there, and planning the spatial arrangement of things? Then this might be a good career for you!

In college take engineering (I took a course in highway design that I loved) and math classes, and intern for a local city's public works department, to learn the plans of garbage pick-up, synchronizing traffic lights and so on.



Computer Scientist



Computer Scientists combine engineering, programming and trouble-shooting all into one career. As a **Computer Scientist**, you work on many different projects and you can work in many different industries. Perseverance is very important. You can't be discouraged when something doesn't work correctly the first time. You use your creativity and problem solving skills to try, try again!

As a **Computer Scientist**, you might write a new code sequence and test it for bugs or errors. The annual salary is \$51,391 which is about \$24.70 per hour.



Lauren Tsung
Degree in Computer
Science

Lauren's Biography:

I wanted to be an engineer from a very young age. Through studying, networking, and having faith in myself, I became a software designer. I use my engineering know-how to make my designs user-friendly and technically-smooth. At Yahoo! I am an interaction designer, so I help to decide how the site looks and works.

At an amusement park, I would design the look and feel of the computer-operated rides and arrange the park's computer components.

How to do it:

To become a **Computer Scientist** like Lauren, volunteer in the audio/visual or computer lab at your school to become familiar with computers and equipment. Take a variety of classes in college (I recommend Human-Computer Interaction, software engineering, graphic design, psychology, math and statistics, technical writing, and speech communication) to learn all of the different skills needed to design computer software. Look for opportunities to job shadow (that's networking!) someone in the field.

Coaster Car

1 Hour

+ 10 minutes preparation time



Materials:

Per Group

- wheels
- axles (skewers)
- cylinders (straws)
- cardboard
- glue guns
- hot glue sticks
- scissors
- measuring tape
- duct tape
- Engineering Design Process poster

Not Provided

- ramp materials (books, cardboard, etc.)

Grouping: Pairs

Introduction: In this activity, girls will create a small car powered by gravity.

Objectives: As a result of this activity, the girls will be able to:

- ☀ Describe how a wheel and axle works as a simple machine
- ☀ Explain how gravity can be used as an energy source

Science Behind It:

In this activity, you are transferring potential energy into kinetic energy.

Potential energy is stored energy that can be released. For example, a stretched rubber band has potential energy because it will move when you let it go. When you put a car at the top of a ramp, the car has potential energy because it will move as soon as gravity can act on it. Once the car starts moving, it has **kinetic energy**, or energy of motion. The angle of the ramp, friction between the wheels and the ramp, and friction between the cylinder and axle will all affect the car's energy.

A wheel and axle is a type of simple machine (as you learned in Session 1). In order for these to move a load, the axle must be able to turn freely. Encasing the axle (a skewer) in a cylinder (a straw), and attaching the cylinder to the car, allows the axle to turn freely.

Preparation:

- **Arrange** the ramp and use the measuring tape to mark a line 2 feet beyond the bottom of the ramp. The ramp can be as long or as steep as you like, but once the ramp is set up, do not change or move it.

Opening (5 minutes):

1. **Explain** that today the girls will be challenged to build a roller coaster car. They need to build a gravity-powered car that will roll down a ramp and travel as far as possible.
 - The car may not have any human energy inputs (pushing).
 - The car must have at least three wheels. Wheels are defined as round objects that rotate.

Coaster Car

Brainstorm (10 minutes):

2. **Group** the girls into pairs and have them brainstorm how they might design and build their car. Explain that they will let go of the car at the top of the ramp, so it can roll freely down the ramp and as far beyond as possible.
3. **Distribute** materials to experiment with, but no tape or glue.
4. **Experiment.** You may need to help girls brainstorm ways to allow the axle to move freely while keeping a stable connection to the car (such as inserting the axle into a straw and gluing the straw to the body).
 - How will you attach the wheels to the car?

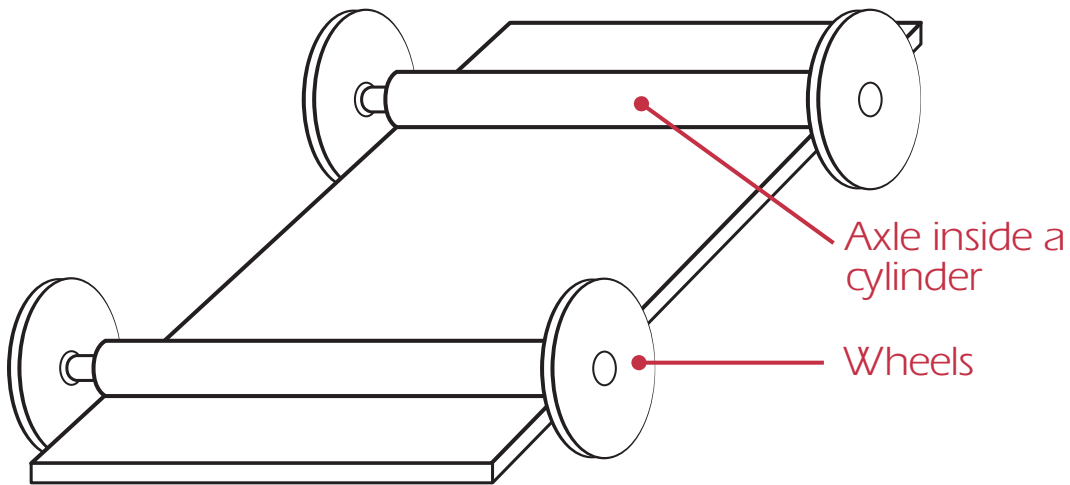
Hands-On (35 minutes):

5. **Distribute** the tape and glue and give the girls thirty minutes to build their cars.
6. **Test** the cars by having each girl place her car at the top of the ramp.
 - How can you make the wheel and axle turn freely?
 - What materials do you think will work best?
 - How far does each car travel?

Reflection (10 minutes):

7. **Lead a discussion** using the following questions as a basis for discussion:
 - How did you create a wheel and axle that move freely?
 - Why is the ramp necessary for making the car roll? *(If you can't push it and there is no motor, you need to get the energy from somewhere. In this car, gravity is pulling on the car and makes it roll down the ramp, so the energy source is gravity.)*
 - How else can you use gravity as an energy source? *(You can use gravity as an energy source by transferring **potential energy** (being at the top of the ramp) to **kinetic energy** (rolling down the ramp) by allowing gravity to act on an object (letting go of the car).)*
 - Which cars moved the furthest? Why?
 - Where else are wheels and axles used?

Coaster Car



Note:

The wheels need to be glued to the axle and the axle must turn freely inside a cylinder.

Gearing Up!

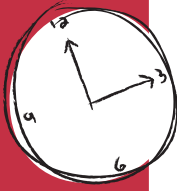
10 Minutes

Materials:

Per Group

- egg beater
- corkscrew
- bicycle bell
- can opener
- ice cream scoop

Grouping: Pairs



Introduction: In this activity, girls will learn about gears as a compound machine capable of doing a variety of work.

Objectives: As a result of this activity, the girls will be able to:

- ☀ Explain how gears work
- ☀ Think creatively about the application of gears

Directions:

1. **Encourage** girls to look, touch and play with these five household items with exposed gears.

2. **Consider** the following questions:

○ What are these items? What do they have in common with each other?

3. **Ask.** After manipulating the tools, ask for volunteers to explain in their own words how the gear works in one of the items.

4. **Brainstorm.** Ask girls to pair up. Distribute one item to each pair. Ask the pairs to brainstorm a new amusement park ride that uses the gears of the item they're holding.

○ How do these gears work? How do they move together?

○ Could this type of gear be used in a part of the ride or in a game?

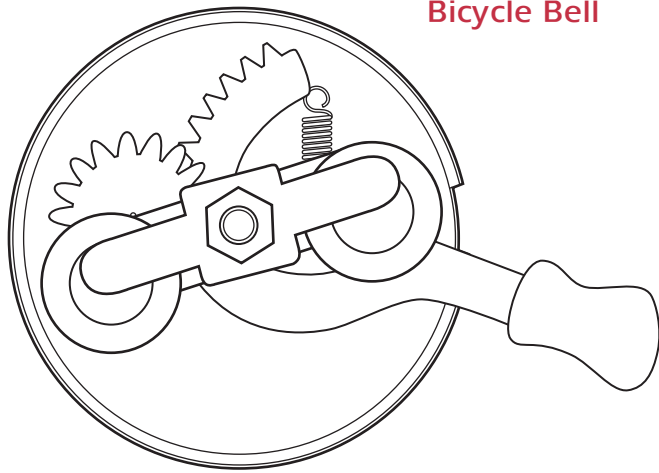
5. **Share.** Allow three minutes to think and talk, and ask each group to share their wacky gear-based ride.

Note:

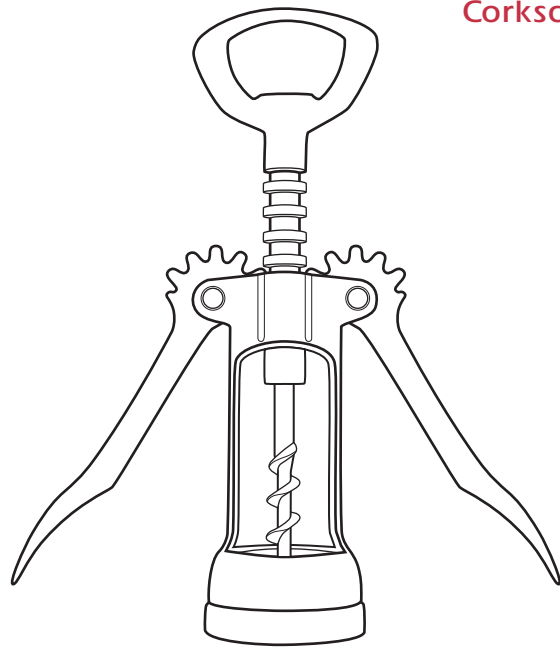
The girls' observations about how gears work in these household objects leads into the **Merry-Go-Round** activity, an application of gears in an amusement park.



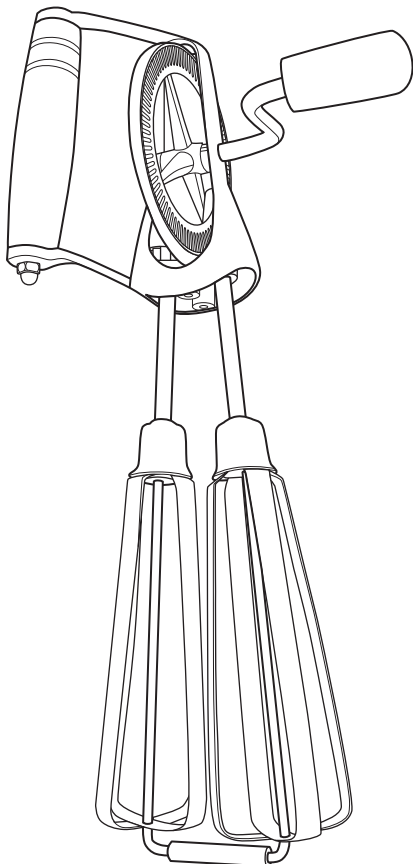
Gearing Up!



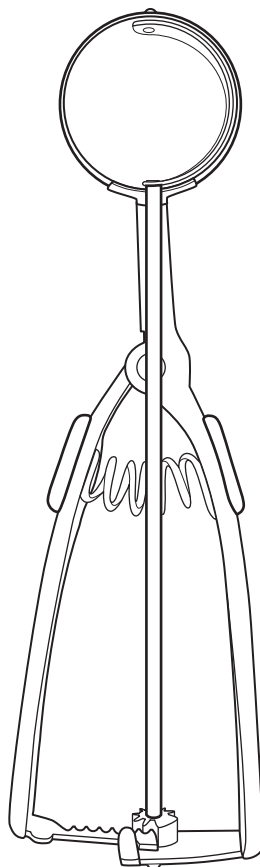
Bicycle Bell



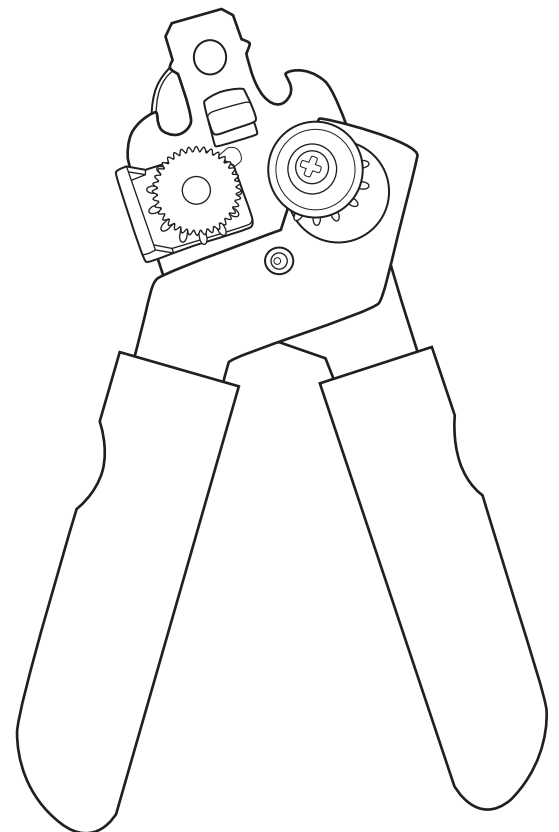
Corkscrew



Egg Beater



Ice Cream Scoop

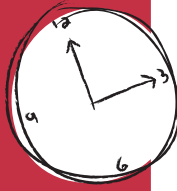


Can Opener

Merry-Go-Round

70 Minutes

+ 20 minutes preparation time



Materials:

Per Pair

- 1 large cup
- 1 small cup
- 2 pointed skewers
- glue gun and glue sticks
- 2 bevel gears
- paper plate
- ruler
- graph paper
- pencils
- pipe cleaners
- Merry-Go-Round handout
- Bevel Gear reference sheet
- 2 Industrial Engineer: Park Plan sheets

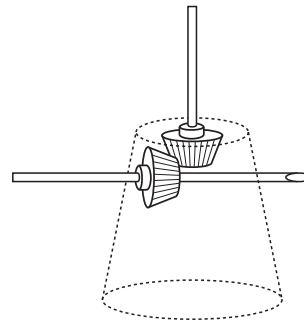
Grouping: Pairs

Introduction: In this activity, girls will use two bevel gears to build a Merry-Go-Round, and efficiently plan the capacity of an imaginary amusement park.

Objectives: As a result of this activity, the girls will be able to:

- ☀ Describe how interlocking bevel gears change the angle of rotation
- ☀ Explain the kind of work that **Industrial Engineers** do

Science Behind It:



Bevel gears have faces shaped like a cone. This means that when they interlock, they rotate at a different angle. The gears can be manufactured to intersect at any angle. When they intersect at 90° , they are also called miter gears.

Gears with different numbers of teeth can also be used to change the amount of force required, or to change the speed of rotation.

Preparation:

- **Organize** supplies so it is easy for girls to access their materials. It is helpful to have two bevel gears on skewers already assembled so you can model how they will work together.
- **Practice.** It is very helpful to complete this activity ahead of time so you can show an example to your group and model the construction.

Merry-Go-Round

Opening (5 minutes):

1. **Explain** that the girls will build a Merry-Go-Round for the amusement park. Pass out the *Merry-Go-Round* handout.
2. The girls will use their knowledge of **Mechanical Engineering** and gears, and take on the role of **Industrial Engineers**:
 - **Industrial Engineers** work to maximize the efficiency of an operation. They consider workers' skills, cost, safety, and equipment to make sure that something works as well as possible. In an amusement park, **Industrial Engineers** design the layout of the rides so that lines move quickly, the rides are well-spaced, and the rides operate smoothly.

Brainstorm (10 minutes):

3. **Group** the girls into pairs and pass out the *Bevel Gear* reference sheet. Have each pair look over the illustration on the front side of the sheet. Think about the following questions:
 - What is unique about these gears? How would you put them together?
 - When one turns, what direction does the other turn? (*At another angle.*)
 - How are these gears similar or different from the gears on a bike or the other things we explored earlier?

Hands-On (40 minutes):

4. **Distribute** the materials. The girls should follow the directions on the *Merry-Go-Round* handout to construct their Merry-Go-Round. Encourage them to work slowly and be careful when inserting the skewer through the cup so they don't rip it. A master cup with pre-drilled holes is included if your girls need help making holes with the proper measurements.
5. **Test.** Once they have completed the construction, test the Merry-Go-Rounds by turning the skewer pointing out the side of the cup. They may need to push the skewer in so the gears interlock. Make sure they don't push too hard or they risk ripping the cup.
6. **Plan.** Girls should get the *Industrial Engineer: Park Plan* sheets (including graph paper) and a pencil, and determine the maximum number of park visitors. After girls share their plans with their partner and compare, they can continue decorating their Merry-Go-Round. The decorative look of the merry-go-round is not of primary importance; understanding the role of an **Industrial Engineer** and gears as simple machines should be the priorities.
7. **Build** seats or carousel animal figures out of pipe cleaners and attach them to the base once the ride is finished.

Merry-Go-Round

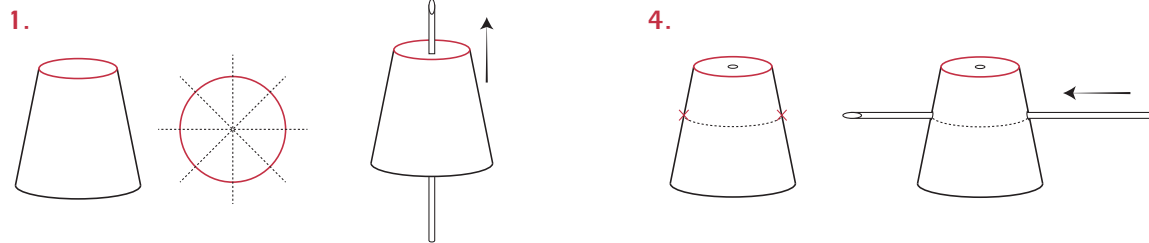
Reflection (15 minutes):

8. **Share.** Have each pair demonstrate their ride, and compare the *Park Plans*. Ask them how their choices maximized the number of visitors.
9. **Lead a discussion** using the following questions:
 - What type of gear is used in this project? What task do these gears accomplish?
 - What else might you use bevel gears for?
 - How does an **Industrial Engineer** help make an amusement park a fun place?
 - What else might an **Industrial Engineer** work on?
 - What did you find challenging or interesting about this activity?

Merry-Go-Round Handout

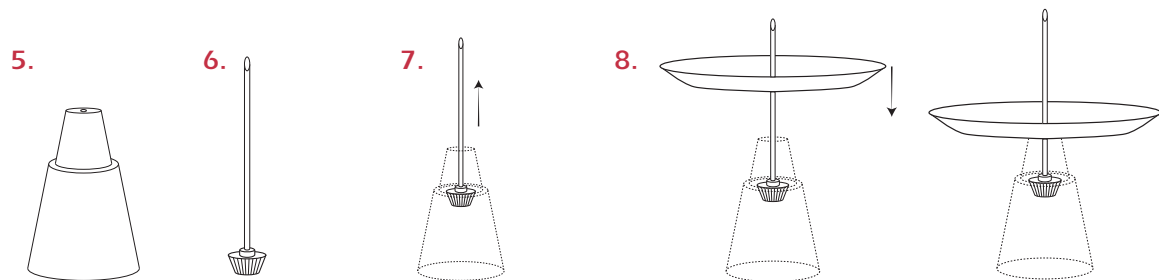
Merry-Go-Round Handout

Make the Holes:



1. To find the center of the bottom of the cup: Set the large cup upside down on your table. Using the ruler, draw a line across the bottom of the cup as close to the center as you can. Draw several more lines using the ruler across the cup in different ways. All the lines should meet at one point, which is the center of your cup. Poke a hole through this point with your skewer.
2. Find the center of your small cup by following the directions above.
3. Find the center of your plate by following the directions above.
4. Measure 1 inch from the bottom (the actual bottom) of the large cup and mark it on the side. Make another mark 1 inch up from the bottom **directly** across the cup (use one of the lines you drew to help). Poke through both holes with the skewer. Slide the skewer back and forth a few times to make the holes smooth. Put the skewer aside.

Build the Vertical Rotation Device



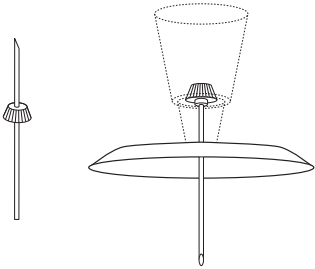
5. With the large cup upside down, place the small cup onto the bottom of the cup, also upside down. Glue the small cup onto the larger one.
6. Get the other skewer and one bevel gear. Glue the gear securely to the very end of the flat end of the skewer with the teeth pointing away from the skewer. Make sure NO glue gets into the teeth of the gear, and that the skewer does not stick out past the gear.
7. From the inside of the cup, insert the end of the skewer through the holes on the bottom of both cups so the gear is inside the cup. Set the cup upside down so the skewer is pointing up out of the bottom of the cup.
8. Place the paper plate on the skewer and slide it down as far as you can, so the plate is against the top cup and the gear is against the inside of the bottom cup.

Merry-Go-Round Handout

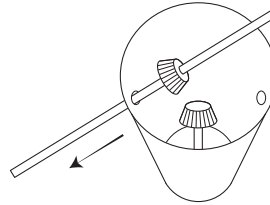
Merry-Go-Round Handout

9. Pull up on the skewer so it doesn't slide down and glue the plate to the skewer. Be sure that no glue drips down and attaches to the cup. Hold the skewer in place until the glue dries.
10. Once the glue is dry, gently spin the skewer to be sure the plate, skewer, and gear rotate together.

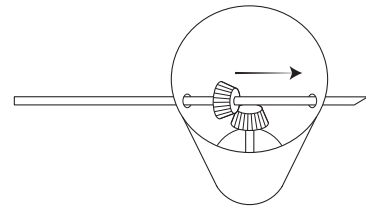
12.



13.

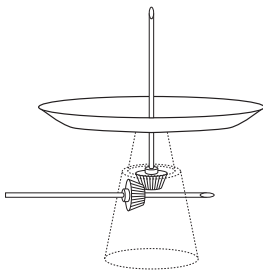


14.



Build the Horizontal Rotation Device

11. Take the other skewer. Measure 2 ½ inches from the flat end and mark it.
12. Glue the other gear onto the skewer so the smooth, round part of the gear is at the 2 ½ inch mark. The teeth should face the shorter, flat end.
13. Angle the long end of the skewer into one of the side holes from the inside of the cup.
14. Slide the skewer in as far as you can. Angle the other end down and push it through the opposite hole.
15. Once the horizontal skewer is in place, set the cup down so that the plate is on top. Push the long end of the skewer coming out the side of the cup and gently inwards so the gears engage.
16. Twist the skewer end and watch the plate rotate!



Complete the Industrial Engineering challenge on other sheet.

Now that you know how many riders should go at one time, create seats for the Merry-Go-Round and try out your ride!

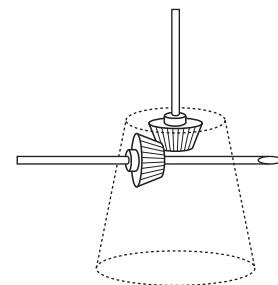
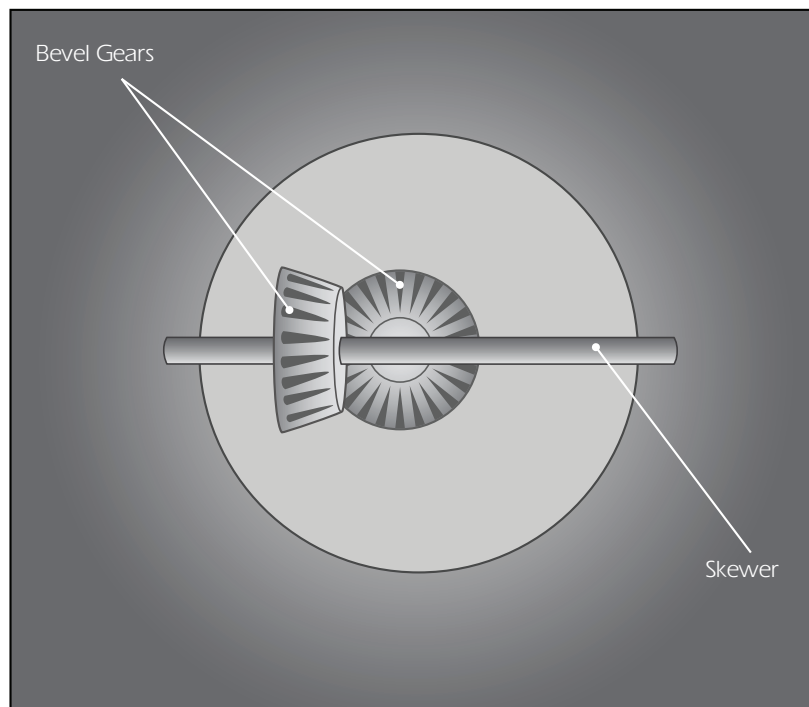
Bevel Gear Reference Sheet

Bevel Gear Reference Sheet

Build a bevel-gear Merry-Go-Round

Look at the picture below. Can you identify the gears? When you turn the horizontal skewer, what will happen?

Bevel Gear Top View: Looking into Cup



Note: The gear is attached to a stick inserted into the side of the cup.

Industrial Engineer: Park Plan

Industrial Engineer: Park Plan

As an **Industrial Engineer**, you want to maximize the number of people you can entertain at one time. Plan your park on the graph paper provided. How many people can safely fit?

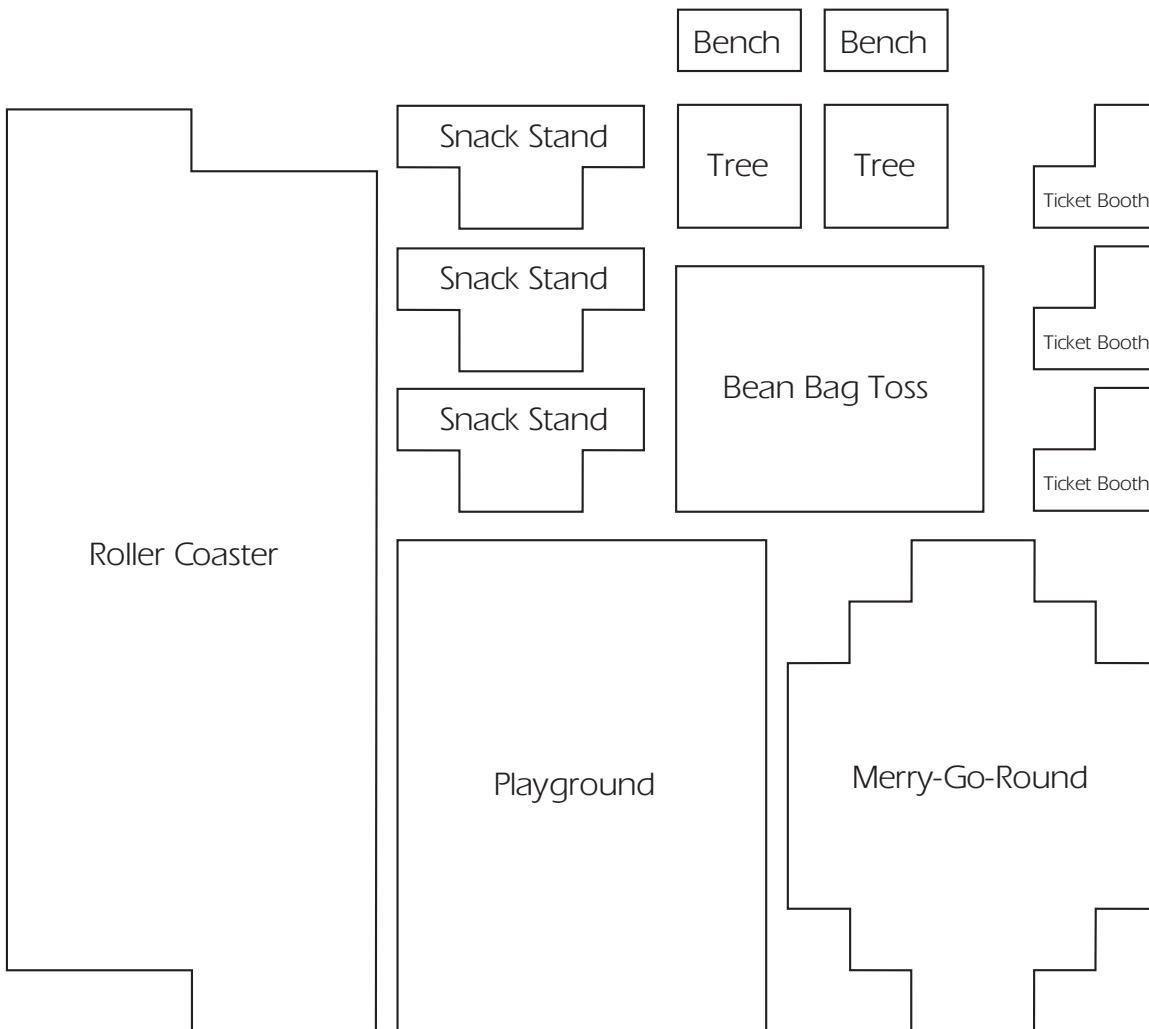
You must place each of the pieces below into the park area, leaving as many square 2×2 blocks empty as possible. Each 2×2 square represents ten people.

Group	
of 10	

Here are the placement rules:

1. Walkways must be two squares wide
2. The four major attractions must be at least two squares away from each other to allow for a walkway
3. Any remaining empty blocks (that aren't 2×2 squares) do not count toward your maximum visitor capacity

----- -cut these out-----



ThrillBuilders

Your Career Card

20 Minutes

Materials:

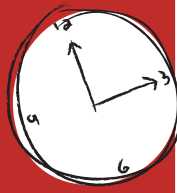
Per Girl

- 1 blank career card
- 1 pencil

Per Group of 10

- 2 sets of 5 role model career cards
- 2 boxes of permanent markers

Grouping: Individual



Introduction: In this activity, girls will think about their futures and create a role model career card about themselves.

Objectives: As a result of this activity, the girls will be able to:
 Illustrate future career plans
 Consider career options

Preparation:

- **Optional.** Take and print headshot photos of your girls ahead of time and attach them to the cards.

Directions:

1. **Pass** around the role model career cards from this box and give the girls a chance to become familiar with them. Discuss some of the projects they have done so far and some of the careers they have learned about during those activities.
 - What kind of designer designs computer programs?
 - What kind of designer makes plastic, cloth or other similar things?
 - What does a **Mechanical Engineer** do?
2. **Explain** that they will be making their own career cards today. Girls will need to choose a career from the career cards.
3. **Ask** them to think about what college they might attend for this career and what degree they might have. Would they like to have a family? Where do they see themselves living?
4. **Give** the girls ten minutes to make cards for themselves modeled after the role model cards in your box. If any girl is having trouble choosing a career, ask her to think back on what activity she liked the best or what career she thought was most interesting.
5. **Present** these career cards to the group. Discuss why girls chose a specific career.
 - Why did you choose this career for yourself?
 - What other things do you hope to accomplish in your future?
 - Explain why science and engineering are good careers for women.

Your Career Card

Your Career Card			Techbridge
Picture	Biography:	At my job, I work on...	
	Interesting Facts:		
Name			
Occupation			
Degree in:			

Your Career Card			Techbridge
Career Activity:	Biography:	At my job, I work on...	
Career Catcher	Interesting Facts:		
Picture			
Name			
Occupation			
Degree in:			

Fling It!

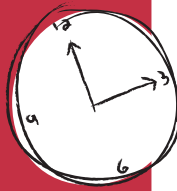
20 Minutes

Materials:

Per Pair

- plastic spoon
- cotton ball
- spool
- skewer
- rubber band
- masking tape

Grouping: Pairs



Introduction: In this activity, girls will design and build the pivoting arm for the Bean Bag Toss in the amusement park.

Objectives: As a result of this activity, the girls will be able to:

- ✧ Explain the importance of a rotating pivot arm in a catapult
- ✧ Explain how elastic potential (stored) energy is converted to kinetic (motion) energy when it is released
- ✧ Identify places where simple machines are used in a catapult device

Opening (2 minutes):

1. **Inform** the girls that they will build a Bean Bag Toss game for the amusement park.
2. **Lead a discussion** about how things can be launched in the air or experiences that girls may have had with things like food fights, sling shots, and trampolines. Possible discussion questions include:
 - What kinds of devices launch objects into the air?
 - How do those devices get the force they need to launch things?

Brainstorm (3 minutes):

3. **Distribute** a spoon and cotton ball to each pair and have them brainstorm different ways to use the materials to launch the cotton ball at something.
 - How were you able to launch your cotton ball?
 - Where did the force (or oomph) come from?
4. **Emphasize** the importance of human energy input and having a pivoting, or rotating, arm to launch the cotton ball.

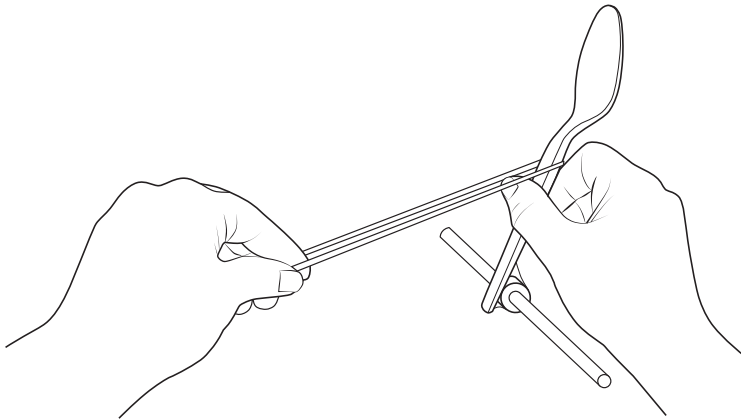
Fling It!

Hands-On (10 minutes):

5. **Hand** each pair of girls a spool, a skewer, and masking tape.
6. **Inform** the girls that they must launch the cotton ball without moving their wrist, and they must build something that pivots on its own.
7. **Instruct** the girls to use all the materials they have to create a rotating arm that launches the cotton ball. *(This can be done by taping the spoon directly to the spool. The skewer should be inserted through the spool so that it can rotate freely.)*
8. **Consider** the following question:
 - Why is a pivoting arm important?
9. **Hand** each pair a rubber band. Instruct them to use the rubber band to provide the force to make the arm swing.
10. **Lead** a discussion using the following questions:

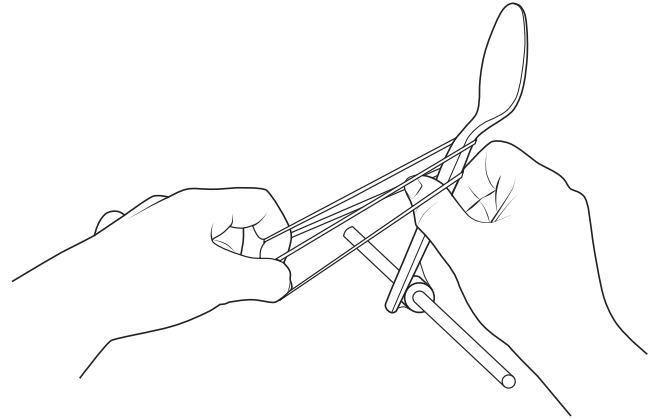
Sample Position 1:

Stick the spoon through the rubber band.



Sample Position 2:

Wrap the rubber band around the spool.



- How were you able to use the rubber band to provide the force to launch the arm?
- Why is it important for the arm to rotate freely instead of being taped in place?

Reflection (5 minutes):

11. **Facilitate** a discussion using the following questions:

Note:

This icebreaker is an introduction to the following **Bean Bag Toss** activity. Before moving on to the activity, make sure girls understand that the rubber band should be anchored in front of the pivoting arm. The rubber band provides the energy, so it must snap forward.

Fling It!

- How can you apply what you learned in this activity to something in your daily life?
- What simple machine can you find in the device you just made? (*Lever and fulcrum.*)
- Where did the energy to move the cotton ball come from? (*From you, to the rubber band, to the cotton ball.*)
- How might this device be used?

Bean Bag Toss

70 Minutes

Materials:

Per Pair

- Building A Bean Bag Toss handout
- pencil
- 50 craft sticks
- 10 rubber bands
- 4 spools
- 4 skewers
- bean bags or other small projectiles
- 3 cardboard squares

Per Group

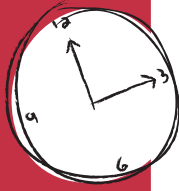
- scissors
- hot glue guns and glue sticks
- extension cords

Not Included

- scratch paper
- bowl/target (optional)

Grouping: Pairs

Or individually if materials and time permit.



Introduction: In this activity, girls will use craft sticks and the pivoting arm from *Fling It!* to build a miniature catapult that launches small pouches. This will be a Bean Bag Toss carnival game in their amusement park.

Objectives: As a result of this activity, the girls will be able to:

- ☀ Explain how a lever and fulcrum function as a simple machine
- ☀ Explain how the stored energy in the rubber band powers the lever
- ☀ Describe what a **Safety Engineer** does

Science Behind It:

A catapult is really just a lever and fulcrum. The long arm is the lever, which rotates around a fulcrum. The rubber band, when stretched, contains elastic potential energy, which is transformed into kinetic energy (energy of motion) when you let it go.

The more elastic potential energy you can store in the rubber band, the more energy will be transferred to the lever, which in turn will launch the bean bag a longer distance.

Note:

Completing the **Fling It!** icebreaker on page forty-four is crucial for the girls to understand the basic mechanics of the device. Be sure to complete the icebreaker before doing this activity.



Bean Bag Toss

Opening (10 minutes):

1. **Clarify** to the girls that they will use the lever and fulcrum they built in the *Fling It!* icebreaker to build a Bean Bag Toss (catapult) carnival game. The object of the game is to launch the bean bag into a target.
2. **Explain** that with their knowledge of **Mechanical Engineering**, they will take on the role of **Safety Engineers**:
 - What do you think **Safety Engineers** do?
3. **Distribute** the **Safety Engineer** career card and review it with the girls. **Safety Engineers** look at the design of something, see what problems could arise, and think of ways to fix the potential problems. As a group, consider the following questions:
 - How do you think they might be involved in an amusement park? (*The **Safety Engineer** might troubleshoot seat belt problems on rides, or make sure the walking paths are level.*)
 - What might a **Safety Engineer** think about when designing this game?
4. **Distribute** the *Bean Bag Toss* handouts.
5. **Examine** the rotating arm built during the *Fling It!* icebreaker.
 - What part of the catapult does this arm and rotating device relate to?
 - How will you use the arm you built in *Fling It!* in your catapult?
6. **Facilitate** a discussion on how the *Fling It!* icebreaker relates to the pictures on the handout, and what else they need to build to complete their catapult. You want the girls to understand that the arm they have already built is the lever and fulcrum (pivoting arm) of the catapult. They will need to build a base and support structure for their pivoting arm, and will need to build a place to support the rubber band so that it will stretch as the arm is pulled back.
 - What part of the catapult have you already built?
 - What other parts of the catapult need to be built?
 - What is the purpose of a base and support?

Brainstorm (10 minutes):

7. **Plan.** Allow girls to see the supplies available.
8. **Sketch.** Have each pair brainstorm and sketch a few ideas of what they think an effective launching device for bean bags might look like. Remind the girls that the support for the arm should allow it to rotate back and forth.

Bean Bag Toss

Hands-On (40 minutes):

9. **Create.** Have each pair use their sketch to build their device and create a prototype or test design.
10. **Consider.** Remind the girls that the rubber band must be attached so it stretches when you pull the arm back with your hand. Review the pictures for inspiration if needed. The **Safety Engineer** must be sure their bean bag toss launches correctly each time. The bean bags must go straight ahead and land within the playing area (set up to the leader's discretion).
 - How are you going to create elastic potential energy when you pull the arm back? How will it be transformed into kinetic energy? *(When you stretch a rubber band, it has potential energy because it will move as soon as you let it go. Once the rubber band moves, the stored energy becomes kinetic energy.)*
11. **Test** the catapults in front of the group. Place a target or bowl about 10 feet from the testing area. Each pair should try to toss their bean bag into the target. You may choose to move the target depending on the success of their devices.
 - What are some safety issues that might come up when you are building or testing your catapult?
12. **Redesign.** Allow girls to redesign their catapults and test them again.
 - Why is it important to make sure the bean bag lands within the playing area?

Reflection (10 minutes):

13. **Lead** a discussion with the following questions:
 - What simple machine was used in this carnival game? How did you build it so it moves? *(A lever and fulcrum.)*
 - How did you use the rubber band to store energy to power your Bean Bag Toss?
 - Why is it important to have the rotating arm move freely around the spool, or fulcrum?
 - What else would a **Safety Engineer** work on at an amusement park? What about a **Mechanical Engineer**?
 - What did you find challenging about building this carnival game? How did you overcome this challenge?

Note:

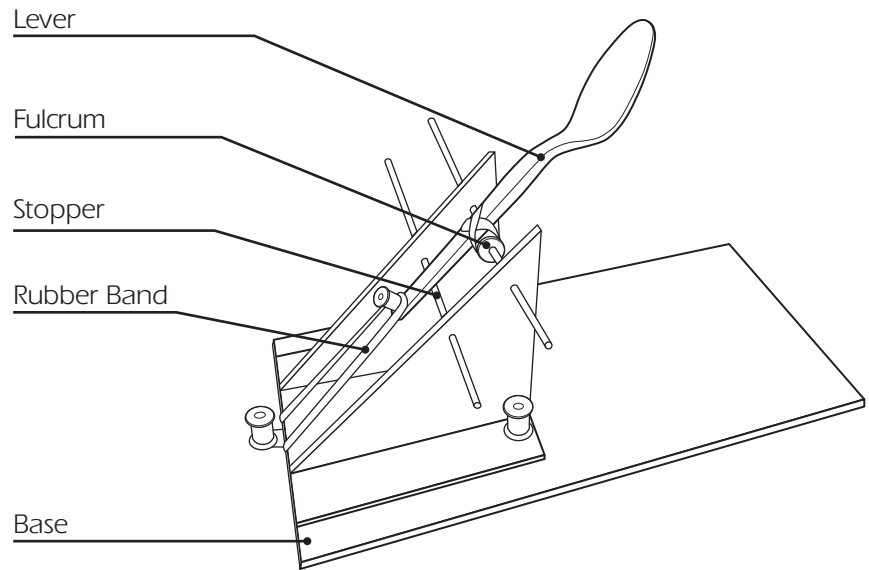
You can make the carnival game more complicated by providing smaller and larger targets for the girls to hit. You can also hold a "Bean Bag Toss Olympics" and give out awards for accuracy, distance, height, etc.



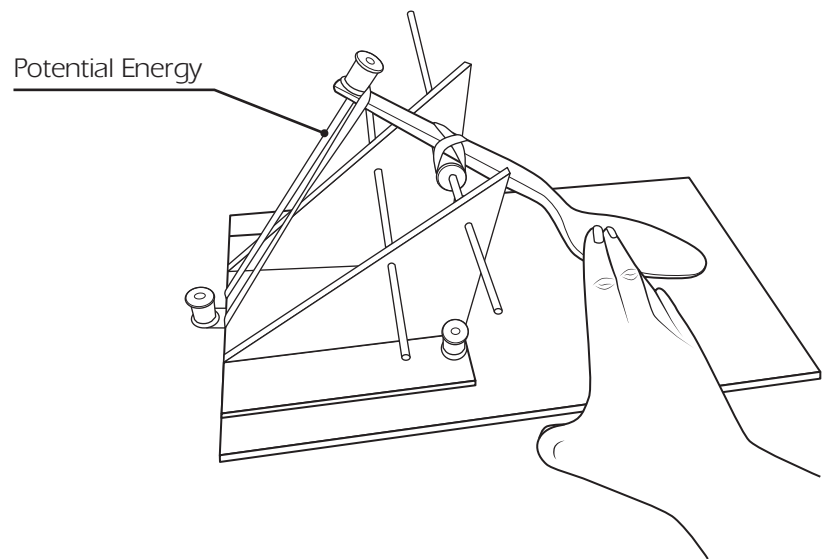
Bean Bag Toss

Note that the lever (spoon) is attached to the fulcrum (spool), but the fulcrum is rotating freely around the support (skewer).

This model also includes a “stopper” device behind the lever. This stops the rotation of the pivoting arm so the projectile is launched up and out when the cup stops rotating.



By pulling the spoon back, elastic potential energy is being stored in the rubber band. This potential energy will be released into kinetic energy. When the rubber band “snaps back,” the lower end of the spoon will rotate down, making the round end rotate up.

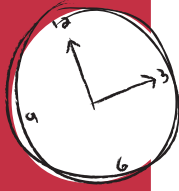


Career Catcher

10 Minutes

Materials:

- scissors
- Career Catcher handout



Introduction: In this activity, girls will review the six careers that are introduced in this program.

Objectives: As a result of this activity, the girls will be able to:

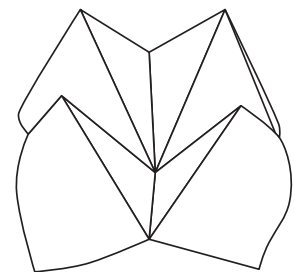
- ☀ Identify a key task associated with **Industrial, Mechanical, Safety, Structural, and Transportation Engineering, and Computer Science**

Hands-On (5 minutes):

1. **Cut** out the square and turn the writing side face down. Take the bottom right corner and fold diagonally so that the corner touches the left side. Press the crease to make a triangle. Open to a square.
2. **Fold** the bottom left corner so that the tip is in the center of the square. Press flat and leave folded. Fold the bottom right corner so the tip is in the center of the square. Repeat with two remaining corners, leaving them folded down.
3. **Flip** the folded paper over. Fold a corner inward so that the corner tip again meets in the middle. Press each fold flat. Repeat for each corner.
4. **Fold** the square in half. Press the fold down. Unfold. Fold the square the other way.
5. **Insert** your pointer fingers and your thumbs into the four flaps.
6. **Present** it to a partner and ask them to pick one of the four hands-on activities we've done in the *ThrillBuilders* program. Then spell that choice out as you move the career catcher backwards and forward for each letter.
7. **Show** the inside, revealing a simple machine, to your partner. Ask them to pick one. Spell it out and move the catcher backward and forward for each letter. Ask your partner to pick one more simple machine.
8. **Lift** that flap to reveal a job description. Read it and ask them to guess who am I? Check if their answer is correct!

Reflection (5 minutes):

9. Lead a wrap-up with the following questions:
 - What skills do you think all engineers have in common?
 - Which of these careers is most appealing to you? Why?
 - If you previously played *Illustrate Your Career*, have any of your preferences about a future job changed since then? If so, why?



Completed Career Catcher

Career Catcher

Carousel	Wedge I design and test the moving parts of a machine.	Screw I test products and sure people using them are protected.	Bean Bag Toss
Lever I use science and creativity to solve the world's problems.	Every Engineer Mechanical Engineer	Transportation Engineer Safety Engineer	Gear I work to move people and things safely and efficiently.
Inclined Plane I design and build the bones of a building so it stays upright.	Structural Engineer Industrial Engineer	Computer Scientist Mechanical Engineer	Axle I design and develop software programs.
Playground	Pulley I find ways to save money, time, and resources while making a product.	Wheels I make sure any moving part of a product works safely and well.	Coaster Car