JUNIOR ENGINEERS

DESIGNED FOR GRADE LEVELS - 3 TO 5

WRITTEN BY JAMES SCHRANKLER

Project coordinated by
Saint Paul Public Schools Community Education
in collaboration with St. Paul Sprockets Network

Funding for this project has been provided by:

Course Name: Junior Engineers

Course Description:

Participants explore the engineering process as they build and experiment with mini-roller coasters, design and build bridges, design and test wind powered cars and much more!

Additional Program Resources:

US NSF - *Engineering* Classroom *Resources*
*www.nsf.gov/news/classroom/**engineering**.jsp*
Engineering* is *Elementary®
legacy.mos.org/eie/

MN State Standards Addressed:

Benchmark: 5.1.1.2.2
Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in an investigation
Benchmark: 4.1.3.3.1
Describe a situation in which one invention led to other inventions.
Benchmark: 4.1.2.2.2
Generate ideas and possible constraints for problem solving through engineering

Program Quality – Youth Program Quality Assessment (YPQA)

St. Paul Public Schools Community Education identifies quality programming as: safe, supportive, interactive and engaging. Simple, specific examples of program-design related goals are below.

Safe Environment (Physical and Psychological)

- Be on time
- Choose healthy foods
- Choose appropriate activities for your space
- Choose age-appropriate & inclusive resources (music, images, etc.)
- Maintain school-day norms (no running, respectful of space)
- Manage classroom behavior for the safety of all
- Follow safety procedures and be prepared for emergencies

Supportive Environment

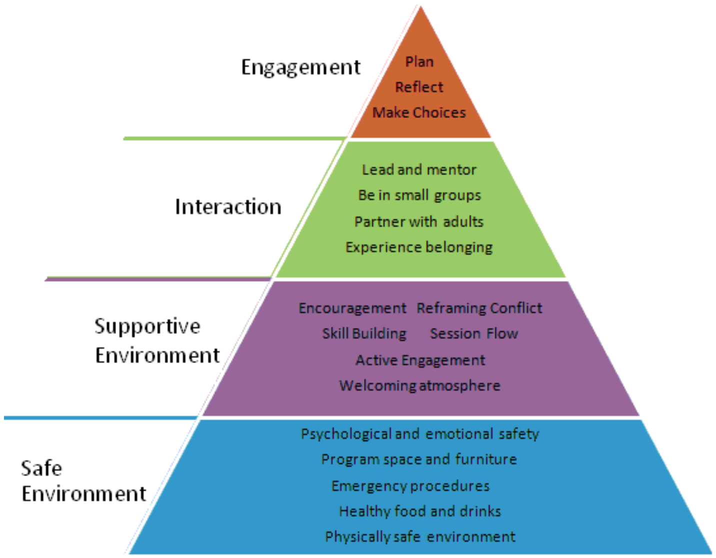
- Be inclusive of different learning styles, cultures, abilities and family structures. Utilize diverse images, games, music, etc.
- Choose encouraging words and develop an encouraging learning environment
- Maintain a professional appearance and wear staff identification
- Use group work, partnering, and aid in building relationships

Interaction

- Youth partner with each other and adults
- Regardless of age - have high expectations for all participants
- Encourage youth choice and self-directed learning opportunities
- Develop a learning environment where youth experience belonging
- Be prepared so you have time for youth choice and adult/youth interaction

Engagement

- Activities are hands-on and encourage multiple types of learning
- Include and facilitate youth choice
- Activities are challenging
- Reflection – all classes end with a reflection question and discussion time



PROGRAM QUALITY – INTENTIONAL INCLUSIVITY

Instructors are expected to **intentionally create inclusive environments.** Examples include:

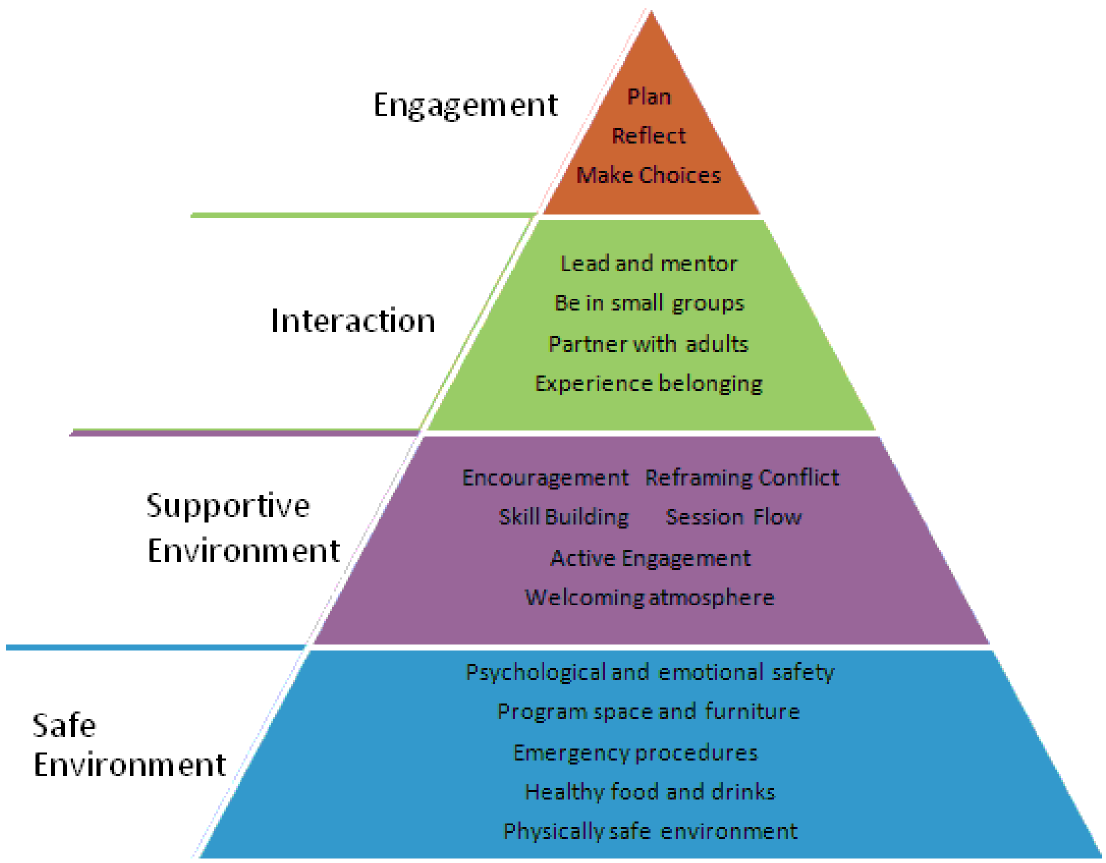
- Use images/books/music, etc that is diverse across age, gender, ability, race, culture, nationality, sexual orientation, etc.
  Example: if you are leading a session on the Winter Olympics include athletes/sports from the Paralympics and Special Olympics, athletes from multiple countries, etc.

- Religious holidays are not neutral and should only be used as a relevant instructional tool.
  Example: Learning about Dia de los Muertos as a cultural celebration in Spanish class is a relevant instructional tool. Making Christmas ornaments in an art class or doing an Easter egg hunt in dance class are not relevant instruction.

- Use inclusive language when talking about families.
  Example: Say "bring this home and show it to someone you love" or "share this with your family" rather than saying, "bring this home to your mom and dad." Do not make assumptions about family structure.

- Create learning opportunities that draw on multiple learning styles.

- Create flexible plans to find time to draw on the unique passions and abilities of your group of youth.



Curriculum Quality – What is GANAG?

GANAG refers to a teaching schema where "a instructor using the 'Teaching Schema for Master Learners' designs session deliberately so as to prepare participants for learning, help them connect new information prior to learning, and cement those ideas or skills. When the schema is used regularly for planning, it becomes automatic to think about teaching to the master learner" (Pollock 64).
Concepts and ideas presented in the following table are extracted from Jane Pollock's text, *Improving Participant Learning One Instructor at a Time*.

G **Set the Goal/Benchmark/Objective**	Instructor (and/or youth) identifies goals/benchmarks for a session along with specific daily content objectives. At the end of the day's session, the instructor and participants can evaluate if they have accomplished their goals and whether to move on or perhaps re-visit concepts if needed.
A **Access Prior Knowledge**	The goal is to provide stimulus that relates in some way to the session content. The instructor plans an activity, question or demonstration to spur connections to previous learning, life experience or knowledge of subject matter.
N **Acquire New Information**	Present new information to youth through a variety of activities – ideally connecting to their senses (i.e. hearing a presentation or a lecture, seeing a video, hands-on cooking, etc.). Additionally, sessions include a combination of declarative and procedural content. Declarative = facts & information. Procedural = skills & processes.
A **Apply Knowledge**	Knowledge gains meaning if you can apply it again in a reliable and accurate way. Youth need hands-on opportunities to explore, test, challenge, and apply content.
G **Generalize or Summarize**	A reflective exit activity that demonstrates youth understanding is essential in providing teaching for mastery learning. Reflection allows youth the time to synthesize their experience/learning within the context of the group. Additionally, this element provides instructors with insight on participant learning and guidance on pacing future sessions.

Session Layout – Scope and Sequence

Theme 1	**Session 1:** **Roller Coasters 1**	**Session 2:** **Roller Coasters 2**	**Session 3:** **Roller Coasters 3**	**Session 4:** **Roller Coasters 4**
Theme 2	**Session 5:** **Sail Cars 1**	**Session 6:** **Sail Cars 2**	**Session 7:** **Propeller Cars**	**Session 8:** **Balloon Powered cars**
Theme 3	**Session 9:** **Alka Seltzer Rockets 1**	**Session 10:** **Alka Seltzer Rockets 2**	**Session 11:** **Helicopter Design**	**Session 12:** **Parachute Design**
Theme 4	**Session 13:** **Structural Engineering**	**Session 14:** **Tower Building**	**Session 15:** **Bridge Building 1**	**Session 16:** **Bridge Building 2**
Theme 5 **Perform, Teach, Share**	**Session 17:** **Drought Stoppers**	**Session 18:** **Spinning Science**	**Supplementary Session 1:** **Invention Improvement**	**Supplementary Session 2:** **Energy “Snake Eggs”**

FACILITATOR NOTES AND TIPS

- The addendum for this curriculum is broken into two sections:
    - Instructor Supporting Materials – includes background information for key concepts and projects.
    - Junior Engineering Log – This section can be printed worksheet by worksheet or copied in full, stapled and given to youth as their Investigative Journal for the duration of the program. Note: you may want to collect and distribute the journals each program day if this is how you choose to use the materials.

- Materials will need to be purchased ahead of time for many projects. Once you know your number of participants, review the curriculum and prepare for ordering project materials.

- Some program days will work better and make less of a mess if you are not in a carpeted room. There are notes on these curriculum days about space consideration.

- Have fun!

Glossary of Ice Breakers/Warm Ups

1. **3 THINGS IN COMMON** (great for new groups)
   Each participant pairs up with another participant who she doesn't know. They must find three things that they have in common. Then each pair of youth presents their findings to the rest of the group.

2. **SILENT BALL**
   Youth stand in a circle, passing or tossing a ball between them. No one can talk or make noises. Once each person is passed to at least once, the challenge is completed. If people talk or make a noise, the process re-starts until the group can pass the ball silently with each person touching the ball at least once.

3. **I LIKE TO…**
   Sit the group in a circle (adults and children). Ask everyone to think of something that they like to do. Then pick someone to start by telling the group for example "I like to swim". The person to their right will then tell the group what the first person liked and adding what they like to do, for example "Fred likes to swim, I like to walk".
   This continues right around the circle until the last person has to say what everyone likes to do.
   Other members of the group can prompt by miming the activity if anyone falls into difficulty.

4. **ENGINEERING PICTIONARY**
   This game is similar to charades. Give one participant an engineering word and have them draw a picture on the board that represents the word. The other participants guess the word. Some possible words to use are: hammer, thermometer, pizza, roller coaster, stop watch, etc.

5. **TENNIS SHOE DESIGN**
   Put participants in pairs and tell them they are in charge of designing an improved tennis shoe. Have participants draw a tennis shoe and label parts that have at least 5 improvements on it. You may need to give them one example such as lights on the toes for walking at night. Have each group share with others.

6. **BALL PASS**
   The group sits in a large circle and they must pass (roll) a ball from 1 person to the next. However, they must say the person's name that they received it from and who they are passing it to, time them five times to see how fast of a time they can accomplish this task.

7. **SILLY SALLY**

This is a brainteaser. See how many campers can figure out the pattern without giving it away to anyone else.
Tell your campers that you have a really weird friend named Silly Sally.
Silly Sally likes doors but not windows
Silly Sally likes puppies but not dogs
Silly Sally likes the pool but not water
Silly Sally likes Jeeps but not cars
Silly Sally likes kittens but not cats
Silly Sally likes the floor but not the ceiling
The Secret: Silly Sally likes things that are spelled with a double letter For example, Silly Sally likes doors but not windows because doors has a double letter (oo). You can create as many variations as you would like. It depends on how long you would like the game to last!

8. **NAME MEMORY**

Go around in a circle. 1st person says her name; 2nd person says her name and also says the 1st person's name over again, and so on all the way around the circle. The last person has to repeat everyone's name. As a variation, have each person say her name and what plant she would be, if she could be a plant. This way there is more to remember than simply people's names, which makes it more interesting. Or, have everyone say an adjective plus her name, but the adjective must begin with the same letter. For example: Daring David, Ridiculous Rick, Wonderful Wendy, etc.

9. **NAME TOSS**

Here are the common rules:
1) Arrange the group in a circle.
2) One person starts off by saying the name of someone else in the circle and tossing the ball to them.
3) That person then says the name of a different person, and tosses the ball to someone else that has not yet received the ball.
4) That continues until everyone in the circle has received the ball once.
5) Generally, the objective is to pass the ball around the circle without dropping it. If the ball is dropped, the group restarts until completed without dropping.
6) You can add a "thank-you, (name)" from the receiving person if you like.

Session 1 Roller Coasters 1	Goal: Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in an investigation **Benchmark: 5.1.1.2.2** **Guiding Question:** How does the shape of the rollercoaster track affect how the marble rolls down the track	Materials Needed
Ice Breaker/ Warm Up **10 minutes**	**Access prior knowledge:** 1. Introductions: Introduce yourself to the participants and have each participant introduce themselves to the class with a small piece of info (favorite food, worst tasting food, etc) About themselves to the group. 2. Give a brief overview of the class activities and objectives. Go over both their expectations and your expectations. See addendum for sample curriculum on creating Community Expectations. 3. Ice Breaker: Tennis Shoe Design!	• Paper and pencil
Engineers **10 minutes**	**New information:** "What do engineers do?" Discuss what engineers do by reviewing the engineering design process as a group	• "You are an engineer" image in addendum
Log 1 **25 minutes**	**Application:** How does the shape of the roller coaster track affect how the marble rolls down the track? What makes the marble roll down the track? Demonstrate to participants how to roll the marble down the track. Remind participants to stand on the floor and not on top of tables or chairs. Pass out materials and have participants work in groups of 3. Grouping strategies: Number off by 3's before each session. If groups are working well together no need to change groups before each session. Other ways of grouping: 1. Each youth puts a shoe in the middle of circle, instructor pulls out a number of shoes for each group of participants. Your shoe group determines your working group. 2. Poll participants on favorite foods. No two favorite food types can be in the same group. Instructor assigns based on that information. They can record their findings on a white board if it is available. The findings may include drawings or explanations. Walk around room and provide group support when needed.	For each group of 3 participants: • Stopwatch • marble foam roller coaster track (3" cut foam pipe insulation) • pencil • paper • marble • calculator • Engineer Discovery Log 1 (see addendum)
Reflection Activity **15 minutes**	**Generalization:** Have participants gather and meet together in a group. Have each group report out how they changed their track and how it made a difference in how the marble rolled down the track. Together as a whole group ask participants to "list possible variables they could change that they could use for their investigation during the next class." "How could you test the impact of one of the variables?"	

Suggestions for making today's activities more challenging:
Assign group's different challenges like seeing if they are able to make the marble go through a loop on their track or even multiple loops.

Suggestions for making today's activities less challenging:
Participants may need multiple demonstrations of a variety of track configurations.

Session 2 Roller Coasters 2	Goal: Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in an investigation **Benchmark: 5.1.1.2.2** **Guiding Question:** How does the shape of the rollercoaster track affect how the marble rolls?	Materials Needed
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** Ice Breaker: Charades. Give select participants words from previous class to act out: marble, roller coaster, track, engineer, etc. Review with participants the expectations covered in the last session and review the engineering design process.	
Variables 10 minutes	**New information:** 1. Ask participants to think of variables that might affect how the marble goes down the track. 2. Pass out materials and have participants work in groups of 3-4 and take a few minutes to explore just as they did yesterday. Gather the participants and list the variables with them: start height, size of track, size of marble, etc.	
Log 2 35 minutes	**Application:** Introduce the following investigative question: How does start height affect the time it takes for the marble to roll down the track? Tell participants they are going to gather data to help them answer the question. See Junior Engineer Log Day 2 in addendum. You will also need blank copies of the graphing sheet. Complete the question, prediction, and steps with participants, having the participants fill it in on their papers. They will gather data and complete chart, graph and claim in their groups. Set up Graph for participants: X -axis should be start height (cm) Y- axis should be time in seconds Allow participants (in groups of 3-4) time to gather and graph data, only graphing averages from the "Avg. time" column. When complete, participants will make a claim. Discuss conclusion as a group and have participants come up with a class claim. "The higher the start height, the faster the marble rolls down the track." Participants should then come up with a list of further investigations (example: how does the size of the marble affect the speed?"	For each group of 3-4 participants: • Stopwatch • marble foam roller coaster track (3" cut foam pipe insulation) • pencil • paper • marble • calculator • Engineer Discovery Log 2 & graphing sheet (see addendum)
Reflection 5 minutes	**Generalization:** "How did you feel completing activity in a group?"	

Suggestions for making today's activities more challenging:
Have participants choose another variable to investigate.

Suggestions for making today's activities less challenging:
Complete the investigation as a class; you could have each group test a start height.

<table>
<tr><th>SESSION 3
ROLLER COASTERS 3</th><th>GOAL: GENERATE QUESTIONS THAT CAN BE ANSWERED WHEN SCIENTIFIC KNOWLEDGE IS COMBINED WITH KNOWLEDGE GAINED FROM ONE'S OWN OBSERVATIONS OR INVESTIGATIONS.
Benchmark: 3.1.1.2.1.
Guiding Question(s): How can you make the marble roll down the track as slow as possible?</th><th>MATERIALS NEEDED</th></tr>
<tr><td>ICE BREAKER/
WARM UP
10 MINUTES</td><td>ACCESS PRIOR KNOWLEDGE:
Icebreaker: Play Engineering Pictionary
Review what was learned yesterday: What was our investigative question? "How did start height affect the speed the marble rolls down the track?" What did we find out?</td><td></td></tr>
<tr><td>POTENTIAL AND
KINETIC ENERGY
15 MINUTES</td><td>NEW INFORMATION:
Introduce the terms "potential energy" and "kinetic energy". Diagram for participants how the marble had potential energy when it was at the start of the track and was using kinetic energy as it rolled down the track. Ask participants to come up with other examples.
See Instructor addendum for background information on Potential and Kinetic Energy

Give them today's challenge. "How can you make the marble roll down the track as slow as possible?" Let participants know that they may use any configuration they would like.</td><td>For each group of 3 participants:
• Stopwatch
• marble foam roller coaster track (3" cut foam pipe insulation)
• pencil
• paper
• marble
• calculator
• Engineer Discovery Log 3 (see addendum)</td></tr>
<tr><td>LOG 3
30 MINUTES</td><td>APPLICATION:
Participants should begin investigating and recording slowest times. Also, have participants diagram shapes of tracks with slowest times on a blank sheet of paper. The instructor may want to share slowest times of groups to motivate other groups to get an even slower time. Give participant groups the opportunity to demonstrate their "slowest tracks" to other groups.
Gather participants and share results. Have participants share diagrams of slowest configurations.</td><td></td></tr>
<tr><td>REFLECTION
ACTIVITY
5 MINUTES</td><td>GENERALIZATION:
"How did your group make decisions about modifications?" "Did a group leader emerge while you were working?"</td><td></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Suggestions for making today's activities more challenging:
Assign participants the task of creating a roller coaster conceptual drawing for a new ride at an amusement park. They should have a scale drawing with multiple loop and turns and a name for their roller coaster.</td></tr>
<tr><td colspan="3">Suggestions for making today's activities less challenging:
Complete the activities and make recordings as a large group</td></tr>
</table>

Session 4 Roller Coasters 4	**Goal: Test and evaluate solutions, including advantages and disadvantages of the engineering solution, and communicate the results effectively.** **Benchmark: 4.1.2.2.3** **Guiding Question: How can you make your marble go through a loop on the track?**	**Materials Needed**
Ice Breaker/ Warm Up **10 minutes**	**Access prior knowledge:** Ice Breaker: Ball Pass- the group sits in a large circle and they must pass (roll) a ball from 1 person to the next. However, they must say the person's name that they received it from and who they are passing it to, time them 5 times to see how fast of a time they can accomplish this task. Review the work done last session, "Which type of track did he marble go down the slowest?"	• Stopwatch and ball
Centripetal Force **15 minutes**	**New information:** Have youth brainstorm a list on the board with any claims they can make about the marble roller coaster system based on previous sessions. Introduce the loop challenge. Show participants a bucket of water and ask them if they think that you can tip the bucket upside down without the water coming out? Demonstrate it and introduce participants to the concept of centripetal force. See Instructor Addendum for background information on Centripetal Force	• Bucket of water
Log 4 **25 minutes**	**Application:** Give participants the loop challenge. "Can you make the marble go through the loop in your track and not fall out just as I did with the bucket of water?" Pass out materials and have participants begin trying to get the marble to go through a loop in the track. Participants will record any observations on their Discovery Log. After participants begin to get the marble to go through some loops, give them the multiple loop challenge. Have participants see if they can get the marble to go through multiple loops.	For each group of 3 participants: • Stopwatch • marble foam roller coaster track (3" cut foam pipe insulation) • pencil • paper • marble • calculator • Engineer Discovery Log 4 (see addendum)
Reflection Activity **10 minutes**	**Generalization:** Ask the participants: "What changes did you make to the track to make it go through the loop?" "What role did you play in the group today?"	

Suggestions for making today's activities more challenging: Have participants determine how the number of loops affects the time it takes to go through the track.
Suggestions for making today's activities less challenging: Complete the loop activity together as a class.

Session 5 Sail Cars 1	**Goal: Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question.** **Benchmark: 5.1.1.2.2** **Guiding Question: What type of sail will make the car go the farthest?**	**Materials Needed**
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** Ice Breaker: Silent Ball Do a group brainstorm on the different ways that you could power a car (motor, push, use gravity, wind). Tell participants that you will be spending the next couple of sessions utilizing wind power.	• ball
Wind 20 minutes	**New information:** Introduce the sail car. Ask participants what they think might be some different variables that could affect how far the sail car travels. (wind speed, sail size, wheel size) Demonstrate how to sue the sail car. Set appox. 14 inches from the fan at medium speed and allow the car to roll as it is powered by the fan. Review how to measure distance on the meter tape.	• Sail car (1 per participant) To purchase sail cars: http://artec-educational.shptron.com/k/search?q=sail+cars • Meter tape • Fan • Junior Engineer Log 5
Sail Cars 20 minutes	**Application:** Pass out sail cars to pairs of participants. Have them in a line and test each car individually. Have participants record their distance on the white board in meters. Gather participants after everyone has at least tested their cars one time and find the average distance traveled.	
Reflection Activity 10 minutes	**Generalization:** Ask participants: "What changes could be made to make the cars travel even further?" "During the next session how might you improve the sail design to make it go further?"	

Suggestions for making today's activities more challenging: Participants could test other types of sails.
Suggestions for making today's activities less challenging: Go through activity together as a class.

<table>
<tr><th>SESSION 6
SAIL CARS 2</th><th>GOAL: GENERATE A SCIENTIFIC QUESTION AND PLAN AN APPROPRIATE SCIENTIFIC INVESTIGATION, SUCH AS SYSTEMATIC OBSERVATIONS, FIELD STUDIES, OPEN-ENDED EXPLORATION OR CONTROLLED EXPERIMENTS TO ANSWER THE QUESTION.
Benchmark: 5.1.1.2.2
Guiding Question: What type of sail will make the car go the farthest?</th><th>MATERIALS NEEDED</th></tr>
<tr><td>ICE BREAKER/ WARM UP
10 MINUTES</td><td>ACCESS PRIOR KNOWLEDGE:
Ice Breaker: I like to…
Review with participants the sail cart design and the average class distance the car traveled</td><td></td></tr>
<tr><td>SAIL DESIGN
40 MINUTES</td><td>NEW INFORMATION & APPLICATION:
Show participants materials they may use to improve their sail design. Challenge participants to use the materials to design a sail that will make their car go even further. Before building, youth will first draw their design in Discovery Log 6.

Participants build their sails according to the design they drew and then test and build the sail. They will record the distance the car traveled using the newly designed sail on the white board.

If time permits, allow participants to do one more redesign.

Gather participants in front of class and go over what differences they noticed from the standard sail to the improved sail. Did it go further? Figure out the class average.</td><td>• Paper cups
• Masking tape
• Construction paper
• Sail cars
• Meter tape
• Calculator
• Junior Engineer Log Day 6</td></tr>
<tr><td>REFLECTION ACTIVITY
10 MINUTES</td><td>GENERALIZATION:
“How did your group work together?” “Did you use more than one person’s idea’s?”</td><td></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Suggestions for making today’s activities more challenging:
Allow multiple designs or add additional materials.</td></tr>
<tr><td colspan="3">Suggestions for making today’s activities less challenging:
Complete an improved design and test as a class.</td></tr>
</table>

<table>
<tr><th>SESSION 7
PROPELLER CARS</th><th>GOAL: IDENTIFY AND COLLECT RELEVANT EVIDENCE, MAKE SYSTEMATIC OBSERVATIONS AND ACCURATE MEASUREMENTS, AND IDENTIFY VARIABLES IN A SCIENTIFIC INVESTIGATION.
Benchmark: 5.1.1.2.2
Guiding Question: How does the number of winds of the propeller car affect how far it travels?</th><th>MATERIALS NEEDED</th></tr>
<tr><td>ICE BREAKER/ WARM UP
10 MINUTES</td><td>ACCESS PRIOR KNOWLEDGE:
Ask participants to recall ways that cars could be powered. (wind, electricity, fuel, etc)
Introduce the propeller-powered car and demonstrate how they are powered.</td><td></td></tr>
<tr><td>PROPELLER CARS
15 MINUTES</td><td>NEW INFORMATION:
1. Lay out meter tape. Pass out cars to each pair.
2. Have participants run their cars down the track.
3. Gather as a large group. On the board or a piece of butcher paper, brainstorm a list of the variables (number of winds) that could affect how far their car travels down the track.</td><td></td></tr>
<tr><td>LOG 7
25 MINUTES</td><td>APPLICATION:
Draw their attention to the guiding question. They are going to see how the number of winds affects how far the car travels down the track.

Using Engineer Log Day 7. Complete the question, prediction and procedures together.
Help youth set up the graph axis:
X = # of winds
Y = distance traveled

Go over claims from each pair of participants. Come up with a class claim.</td><td>For each pair of participants:
• propeller cars
• meter tape
• pencil
• paper
• calculator
• Engineer Log 7 & graphing paper (see addendum)
To purchase propeller cars:
http://artec-educational.shptron.com/k/search?q=sail+cars</td></tr>
<tr><td>REFLECTION ACTIVITY
10 MINUTES</td><td>GENERALIZATION:
“If you had a propeller car, where would you drive it to?” “Who would you invite to join you?”</td><td></td></tr>
<tr><td colspan="3">Suggestions for making today’s activities more challenging:
Have participants try winds not found on chart.</td></tr>
<tr><td colspan="3">Suggestions for making today’s activities less challenging:
Complete data collection together as a whole group.</td></tr>
</table>

Session 8 Balloon Cars	Goal: Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation. Benchmark: 5.1.1.2.2 Guiding Question: How does the number of winds of the balloon car affect how far it travels?	Materials Needed
Ice Breaker/ Warm Up **10 minutes**	**Access prior knowledge:** Review variables covered during previous investigations on roller coasters, sail cars and propeller cars	
Balloon Cars **15 minutes**	**New information:** Background Instructor Review: see addendum article on Newton's Three Laws of Motion. This can be distributed to participants or used only as instructor reference. Introduce the balloon-powered car. Fill the balloon with air and show where the air will exit the car. Ask participants which direction they think the car will travel. Demonstrate how it travels. Introduce Newton's 3rd law. Brainstorm how we could change the amount of air in the balloon and hypothesize how far it will travel.	• Balloon Cars (1 per person) Purchase balloon cars at: http://artec-educational.shptron.com/k/search?q=balloon+cars • Pencils • Meter tape (1 per pair) • Meter stick (1 per pair) • Junior Engineer Log Day 8
Log 8 **30 minutes**	**Application:** 1. Pass out balloon cars and Engineer Discovery Log 8 to each participant. 2. Participants will fill their balloons with 4 different amounts of air and would like for them to measure how far the car travels with each amount of air in it. They will record their findings on the chart. They should record the guiding question on their paper: How does the amount of air in the balloon affect how far the car travels? 3. Demonstrate how to measure the circumference of a balloon. Pass out meter sticks, and measuring tape to participants. 4. Participants gather data Participants gather in front and meet as a group. Ask, "What did you find?" "What is your claim?" Come up with a class claim. 5.	
Reflection Activity **5 minutes**	**Generalization:** "Would you rather own a large balloon car or a large propeller car? Why?"	

Suggestions for making today's activities more challenging:
Have participants graph their data.

Suggestions for making today's activities less challenging:
Complete data gathering as a class.

Session 9 Alka Rockets 1	Goal: Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation. **Benchmark: 5.1.1.2.2** **Guiding Question: How does the particle size of the Alka Selzer tablet affect the time it takes for it to launch?**	Materials Needed
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** Ask participants: "How many of you have seen a rocket launch?" Show rocket launch video: http://www.youtube.com/watch?v=w0VlB19yMDM How are rockets powered? (fuel, air, explosion) Show the balloon demonstration. Tell participants to pretend that the balloon you are holding is a rocket. Fill the balloon with air and release it. What powered the balloon? Do you remember Newton's 3rd law (for every action there is an opposite and equal reaction)? Tell participants that the next two sessions will be about rockets. *If in a carpeted room, move to the gym or cafeteria or outside for the day.*	• Balloon • Computer/projector
Air Pressure 15 minutes	**New information:** Tell participants that their rockets will be powered by air pressure created by placing an Alka Seltzer tablet in water. Demonstrate the reaction by filling a plastic bag half full with water and placing an Alka Seltzer tablet in the bag. Place the tablet in a bag ½ full of water and have participants record their observations in their Discovery Log. (bubbles were created and the bag expanded) Discuss why the bag expanded and introduce air pressure.	• Plastic bag • Alka Seltzer tablet • **Clear** film canister • You can often get free film canisters at photo processing shops. To purchase: http://www.stevespanglerscience.com/product/film-canisters
Rocket Construction 25 minutes	**Application:** Rocket construction 1. Demonstrate how the film canister rocket works. 2. Fill film canister 1/3 full of water. 3. Place ½ Alka Seltzer tablet in canister and place upside down. 4. Observe canister pop. 5. Introduce participants to the rocket parts that they will be adding to their rocket. Demonstrate how to cut 4 fins and have the instructor use the hot glue gun to attach them to the rocket. Use the model magic to make a nose cone on the top. Rockets will dry until tomorrow.	For each participant: • Clear film canisters • Foam sheet • Model magic • Scissors • Paper • Pencil • Junior Engineer Log 9 For class: • Hot glue gun
Reflection Activity 10 minutes	**Generalization:** Review parts of the rocket with participants (nose cone, body fins). Discuss variables that could affect the launch.	

Suggestions for making today's activities more challenging:
Have participants research other rocket types.

Suggestions for making today's activities less challenging:
Assist in rocket construction.

Session 10 Alka Rockets 2	Goal: Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation. Benchmark: 5.1.1.2.2 Guiding Question: How does the particle size of the Alka Selzer tablet affect the time it takes for it to launch?	Materials Needed
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** What makes a rocket launch? (review from yesterday) Review parts of the rocket. (nose cone, body, fins) “How do you think the parts help the rocket fly?”	
Activity Type 1 15 minutes	**New information:** (this activity can also be done outside) What variables do you think could affect how high the rocket launches? (tablet size, amount of water) Today we are going to record how the size of the tablet affects how high your rocket launches. Tape a meter tape to the wall. Demonstrate launch by placing ½ of a tablet in the canister and fill it 1/3 full of water. Launch rocket and record height of launch.	
Log 10 30 minutes	**Application:** Introduce the investigative question: “How does the size of the tablet affect the height of the launch?” Have participants write this in their Engineer Discovery Log. 1. Give directions on how to carry out the investigation. 2. Each participant will test ¼, ½ and ¾ tablet size. They will always use 1/3 canister full of water and record each launch height. Gather participants. Discuss findings and come up with a class claim. *Note: The launch can cause some water to go on floor. It can also be done outside. Have paper towels nearby.*	• Rockets constructed during last section • 2 Alka Selzer tablets per participant • Meter tape • Paper • Pencil • Paper towels • Engineering Log 10
Reflection Activity 5 minutes	**Generalization:** “What are some ways we could power these rockets to go even higher?” “What makes model rocketry interesting to you?”	

Suggestions for making today’s activities more challenging:
Have participants test other variables such as the amount of water in canister.

Suggestions for making today’s activities less challenging:
Complete the tests of the different tablet sizes as a class.

<table>
<tr><th>SESSION 11
HELICOPTER DESIGN</th><th>GOAL: TEST AND EVALUATE SOLUTIONS, INCLUDING ADVANTAGES AND DISADVANTAGES OF THE ENGINEERING SOLUTION, AND COMMUNICATE RESULTS EFFECTIVELY.
Benchmark: 4.1.2.2.3
Guiding Question: Which factors affect how long it takes for the helicopter to hit the ground?</th><th>MATERIALS NEEDED</th></tr>
<tr><td>ICE BREAKER/
WARM UP
10 MINUTES</td><td>ACCESS PRIOR KNOWLEDGE:
Drop a piece of paper to the ground. Ask participants:
What they think slowed the paper down as it dropped? (Air)
Do you think it would drop faster if we crumpled up the paper?
Why did it drop faster when crumpled? (due to air resistance)</td><td>• Piece of paper</td></tr>
<tr><td>ROTO COPTERS
20 MINUTES</td><td>NEW INFORMATION:
Today participants will be constructing a paper helicopter and testing a variable that may affect how long it takes to descend. See addendum for Roto Copter instructions.

Have participants construct 2 helicopters. (Template in addendum)
Demonstrate how to drop helicopters to floor. Discuss variables of the helicopter with participants (wing size, number of paper clips, drop height).</td><td>• Per participant:
• 2 helicopter templates
• 1 pair of scissors
• 6 paperclips
• Engineer Discovery Log 11
• (Optional) Roto Copter instructions</td></tr>
<tr><td>LOG 11
25 MINUTES</td><td>APPLICATION:
Give participants today’s guiding question: How does the number of paperclips affect the time it takes for the copter to hit the ground? Participants also write this in their Log.
Participants will test a combination of 3 different amounts of paperclips on helicopters and record which one hits the ground first. They will test each one three times dropping them from the same height.

Discuss which ones seemed to hit the ground first. (the ones with the most clips because they spun the fastest)
“What are some other ways we could slow down the descent of the helicopter?”</td><td></td></tr>
<tr><td>REFLECTION
ACTIVITY
5 MINUTES</td><td>GENERALIZATION:
“Would you rather ride in a helicopter or a rocket?” “Why?”</td><td></td></tr>
<tr><td colspan="3">Suggestions for making today’s activities more challenging:
Test other variables such as the size of the wings.</td></tr>
<tr><td colspan="3">Suggestions for making today’s activities less challenging:
Complete the activity as a whole group.</td></tr>
</table>

Session 12 Parachute Design	Goal: Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question. **Benchmark: 5.1.1.2.1.** **Guiding Question: Which type of parachute design will be slowest to hit the ground?**	Materials Needed
Ice Breaker/ Warm Up **5 minutes**	**Access prior knowledge:** 1. Review previous session with helicopters. Discuss the concept of air resistance.	• 10 stopwatches • Toy parachutes (1 per participant). Make or available at: http://www.landofnod.com/parachute-man/s100498?a=1081&device=c&network=g&matchtype=
Parachutes **45 minutes**	**New information & Application:** Pass out toy parachutes and paperclips. Have youth record the time it takes to drop a paperclip while standing on a chair and then time a paperclip, tied to a parachute, dropped from standing on a chair. Record drop times on board. Discuss why the parachute slows the object during its fall to the ground. Introduce the paper napkin parachute challenge 1. Lay out materials for each group of 4 participants. Participants will design and construct their own parachutes. 2. Give participants the objective: How can you construct a parachute that will take the longest to hit the ground? 3. Participants should draw their design in their Discovery Log. Building and Testing Parachutes 1. Participants must construct their parachutes according to their design. 2. Participants test to see how long it takes for the parachute to hit the ground from a two-meter drop. 3. Record times on white board. Gather participants. "How did each design and help increase air resistance?"	Per participant: • 4 pieces of string 60 cm. long • 1 Napkin Per small group: • Tape • 4 clothes pins • 4 small paper cups • 3-4 markers • 3-4 pieces of paper • 1 pencil • 1 meter stick
Reflection **10 minutes**	**Generalization:** "Would you ever like to skydive?"	

Suggestions for making today's activities more challenging: Allow participants time to make an additional improved design.
Suggestions for making today's activities less challenging: Give the participants directions on how to improve their design.

Session 13 Structural Engineering	Goal: Use appropriate tools and techniques in gathering, analyzing and interpreting data. Benchmark: 5.1.3.4.1 Guiding Question: Which type of shape can support the most weight? (4 sided, 3 sided or cylinder)	Materials Needed
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** Hold and egg on in the palm of your hand. Squeeze the eggs by the ends. Ask: "Why didn't it break?" Have a class discussion on why it did not break. Now squeeze the egg from the sides. Discuss why it broke this time. Review How to Squeeze and Egg demonstration in addendum.	• 2 eggs
Structural Towers 15 minutes	**New information:** 1. Tell participants that their job is to test the strength of 3 different shapes. Put participants in groups of three 2. Assign an equal number of groups for each shape. Have participants construct six of the assigned shapes (4 sided, 3 sided or cylinder) out of the note cards and tape. (10 Min) 3. Go around the room and test the 6 structures together by laying the textbooks on top of them one at a time until they collapse. 4. Record on the board how many each shape supported for each group. See addendum curriculum: Structural Towers for more information and images Review class data.	• 3 x 5 note cards (6 per group) • 25 textbooks or heavy books • 18 inches of masking tape per group • Engineer Log 13
Log 13 30 minutes	**Application:** Give the class challenge: Make six supports using the note cards and tape that will support the most textbooks. Participants should draw their support design in their Discovery Log before constructing. Go around room and test each design. Test each group of supports as a class. Participants should record the number of books their supports supported before collapsing. Gather participants and review small group data.	
Reflection Activity 5 minutes	**Generalization:** "Why do you think a certain shape (cylinder) was stronger than others?"	
Suggestions for making today's activities more challenging: Have participants try additional shapes.		
Suggestions for making today's activities less challenging: Complete activities as a large group.		

Session 14 Tower Building	Goal: Generate ideas and possible constraints for problem solving through engineering design. Benchmark: 4.1.2.2.2 Guiding Question: Which type of supports must be used to make the tallest tower?	Materials Needed
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** Discuss with participants how during the previous session how a specific design (cylinder) for their supports worked best for supporting the greatest number of books. Introduce today's challenge - Using marshmallows and uncooked spaghetti noodles participants will build the tallest self supporting structure possible. See addendum curriculum: Spaghetti Structures for more information and images	
Spaghetti Structures 45 minutes	**New information & Application:** Pass out materials to pairs of participants. Have participants draw a plan for their spaghetti structure. They will build their structures in teams of two. After all the diagrams are complete, have participants construct their plan. Give assistance when needed. When structures are complete, go around class and measure each structure. Rather than making it a competition, encourage youth to note assets in each design and share how their group made decisions. Gather participants and discuss the qualities of structures that were taller and any similarities they noticed. Some participants may have tried triangular shapes and supports and found that they seemed to be the tallest and most stable. Why do they think they are the tallest?	Per group: • 30 full length pieces of spaghetti • 40 marshmallows • pencils • paper • meter stick
Reflection Activity 5 minutes	**Generalization:** "What do you think your family would say if you said you want to build them a house out of spaghetti?"	

Suggestions for making today's activities more challenging:
Give participants a weight that their structure must support on the top.

Suggestions for making today's activities less challenging:
Complete structure building with participants.

Session 15 Pasta Bridge Building 1	Goal: Generate ideas and possible constraints for problem solving through engineering design. Benchmark: 4.1.2.2.2 Guiding Question: Which bridge design will support the most weight?	Materials Needed
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** Ask participants: "Does the design of a structure affect its' strength?" Refer to previous sessions. Tell participants that today they are going to begin designing and building pasta bridges. The goal is to make it the strongest bridge possible. See Pasta Bridges curriculum in the addendum for more information.	
Pasta Bridges 45 minutes	**New information & Application:** Tell participants that their bridges must span 25 centimeters and be at least 4 cm wide. Tell participants that they will also want to leave at least 5 cm. on each end so it can rest between 2 tables. Inform the participants that the weight will be applied to the middle of the bridge. Discuss strategies for making the bridge the strongest. Pass out materials and have participants draw their design. They will need to make it the actual size of their bridge. Have them make both a top (arial) view and a side view. They may need further instruction on these perspectives. Gather participants and discuss the drawings. Have the participants give specific reasons on why they think their design will be strong. Tell participants that tomorrow they will be constructing their bridge.	For each pair of participants: • 3 long lasagna noodles • 20 pieces of spaghetti • 20 pieces of wheel macaroni • 1 glue gun and 2 glue sticks • 5-10 pieces of construction paper • 1 pencil • 1 ruler • tape
Reflection Activity 5 minutes	**Generalization:** "Do you think that it is easier to build by making a drawing first or building without a plan? Why"	

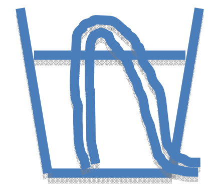
Suggestions for making today's activities more challenging:
Give participants some parameters on the width of their bridges.

Suggestions for making today's activities less challenging:
Construct the bridge in bigger groups or as a whole class.

SESSION 16 PASTA BRIDGE BUILDING 2	**GOAL:** Generate ideas and possible constraints for problem solving through engineering design. **Benchmark: 4.1.2.2.2** **Guiding Question:** Which bridge design will support the most weight?	**MATERIALS NEEDED**
ICE BREAKER/ WARM UP 10 MINUTES	**ACCESS PRIOR KNOWLEDGE:** Pass out participant pasta bridge designs made during previous session. Tell participants that today they will construct their bridges. See Pasta Bridges curriculum in the addendum for more information. *If in a carpeted room, move to the gym or cafeteria for the day.*	
BUILDING BRIDGES 20 MINUTES	**NEW INFORMATION:** 1. Groups gather their materials 2. Review safety in using hot glue guns. Participants must have gloves on when using them. You may choose to do gluing for participants. 3. Remind participants that they must stick to their design and use only the provided materials.	For each pair of participants: • 3 long lasagna noodles • 20 pieces of spaghetti • 20 pieces of wheel macaroni • 1 glue gun and 2 glue sticks • 2 pair of gloves
BRIDGE TESTING 25 MINUTES	**APPLICATION:** Bridge Testing 1. After bridge construction is complete, set up a testing area where you have moved two tables together so there is a 20 cm. gap between them. Test one bridge at a time while the group watches. 2. Place a sting over the top of the bridge in the middle and tie a pail on to the ends of the string. Pour sand into the pail slowly until the bridge breaks. Weigh the sand that it supported and record it on the board. 3. Continue testing all of the bridges in the class. When testing bridges: Try to hang bucket low to the ground to prevent the sand pail from tipping on the floor. Also allow participants to hold on to the ends of the bridges on the table. Answer questions in Discovery Log 16. Go over with participants which bridge designs seemed to support the most weight and why.	For the full group: • Scale • Pail • Sand • String
REFLECTION ACTIVITY 5 MINUTES	**GENERALIZATION:** "What was the last bridge you were on?"	

Suggestions for making today's activities more challenging:
Give participants some parameters on the width of their bridges.

Suggestions for making today's activities less challenging:
Construct the bridge in bigger groups or as a whole class.

Session 17 Drought Stoppers	Goal: Generate ideas and possible constraints for problem solving through engineering design. Benchmark: 4.1.2.2.2 Guiding Question: Using the provided materials, can you construct a Drought Stopper?	Materials Needed
Ice Breaker/ Warm Up 10 minutes	**Access prior knowledge:** Instructor must go to this site before session and find drought stopper. Watch video: http://lhsfoss.org/fossweb/schools/instructorvideos/5_6/ModelsDesigns_flash.html Ask: “Do you know what a drought is?” I am going to show you a new invention that I have come up with called a Drought Stopper. Demonstrate how a small amount of water in makes much more water comes out. Do not show them the inside of the container. 	Pre-make 1 drought stopper per participant unless you can add a supplementary session and have them make the session prior. Drought stopper: • 1 large Solo cup per participant with ¼ inch hole in bottom edge. • 10 inch piece of clear plastic tubing ¼ inch diameter sticking out 1 inch and hot glued around opening. (See image)
Drought Stoppers 40 minutes	**New information & Application:** 1. Have participants draw what they think the inside of the box looks like. 2. Have participants who are willing to share their design share them with the class 3. Show participants what is inside of the box but not the configuration. Pass out cups with tubing inside. Some participants may need extra guidance Distribute cups with tubes and 1 pail of water for each group. Have participants experiment with materials to get the Drought Stoppers to operate. Starting with a given amount of water in the Drought Stopper cup and adding more to make it all siphon out into the bucket. Gather participants and ask them to share what set-up they used to make their Drought Stopper. Discuss the concept of a siphon and tell participants they may take it home and demonstrate on someone at home. See Instructor Addendum for background information on Siphon	• 1 pail of water per group of 3 participants • 1 additional cup per group to pour water from bucket to Drought Stopper.
Reflection Activity 10 minutes	**Generalization:** Ask participants: Who will you show your “Drought Stopper” to tonight? What will you tell them about it?	

Suggestions for making today’s activities more challenging: Provide participants with little guidance during Activity #2, allow them to discover completely on their own.
Suggestions for making today’s activities less challenging: Demonstrate directions step by step as participants construct their Drought Stoppers.

Session 18 Spinning Science	**Goal: Generate ideas and possible constraints for problem solving through engineering design.** **Guiding Question: How can you make a top spin the longest?**	**Materials Needed**
Ice Breaker/ Warm Up **10 minutes**	**Access prior knowledge:** Background info on top construction See Instructor Addendum for supporting curriculum on Spinning Science Ask participants: "What makes a top rotate for a long period of time?" Go over parts of the top with participants (axis and body). Axis-stick in middle Body- large circle on axis	Class tops should be pre-constructed unless you are able to add an additional supplementary session where they are constructed the session prior: • Old CDs • Large shooter marbles • Hot glue
Activity Type 1 **15 minutes**	**New information:** 1. Pass out CD tops and go over parts. 2. Demonstrate how they work. 3. Have participants test tops and time how long they spin from start to finish. 4. Record times.	Per pair of participants: • 1 Constructed CD top • 1 Stop watches • 1 Pencil • 1 set of markers 1 • 1 plastic bottle cap or large metal nut • 8 washers • 1 roll of masking tape
Activity Type 2 **25 minutes**	**Application:** 1. Give participants the Challenge: "Can you make the top spin even longer if you distribute the washers on top of the CD? 2. Have participants draw a top view of where they will tape the washers. 3. Test their drawings and time. 4. Improve design and try again.	
Reflection Activity **10 minutes**	**Generalization:** Gather as a group and discuss which weight distribution seemed to work best. Most participants will find that spreading them out will work best.	

Suggestions for making today's activities more challenging:
Have participants use different size weights. Youth make their own top in an additional session the week prior.

Suggestions for making today's activities less challenging:
Show participants where to tape weights. (The instructor does the hot gluing.)

<table>
<tr><th>SUPPLEMENTARY 1
INVENTION IMPROVEMENT</th><th>GOAL: GENERATE IDEAS AND POSSIBLE CONSTRAINTS FOR PROBLEM SOLVING THROUGH ENGINEERING DESIGN.
Guiding Question: How can you improve on an already existing invention?</th><th>MATERIALS NEEDED</th></tr>
<tr><td>ICE BREAKER/
WARM UP
10 MINUTES</td><td>ACCESS PRIOR KNOWLEDGE:
Ask participants: “What is the purpose of an invention?” (to make life easier)
Have participants brainstorm a list of inventions and discuss how they make life easier.</td><td></td></tr>
<tr><td>ACTIVITY TYPE 1
15 MINUTES</td><td>NEW INFORMATION:
Show participants items, have them select one.
Have them draw the object and any improvements that they could make to them. Instruct them to label and describe their improvement. They must make at least 3 improvements.
Share improvements.</td><td>Variety of everyday objects per group/pair. Examples:
Chair
Cup
Pencil
Shoe
Per participant:
Paper
Pencil</td></tr>
<tr><td>ACTIVITY TYPE 2
25 MINUTES</td><td>APPLICATION:
Repeat the above activity however, this time have participants use an object of their choice.</td><td>Paper
Pencils</td></tr>
<tr><td>REFLECTION ACTIVITY
10 MINUTES</td><td>GENERALIZATION:
Have participants share their improvements with the rest of the group.
“How would you advertise your new invention?”</td><td></td></tr>
<tr><td colspan="3">Suggestions for making today’s activities more challenging:
Have participants begin to build their improved inventions.</td></tr>
<tr><td colspan="3">Suggestions for making today’s activities less challenging:
Complete activities as a group.</td></tr>
</table>

SUPPLEMENTARY 2 **SNAKE EGGS**	**GOAL: GENERATE IDEAS AND POSSIBLE CONSTRAINTS FOR PROBLEM SOLVING THROUGH ENGINEERING DESIGN.** **Discover potential and kinetic energy.**	**MATERIALS NEEDED**
ICE BREAKER/ WARM UP **10 MINUTES**	**ACCESS PRIOR KNOWLEDGE:** 1. Tell participants that you would like to show them some cool snake eggs you have. 2. Carefully have one unsuspecting participant open the envelope. "Snake Eggs!" 3. Ask participants if they really think they are snake eggs.	Instructor should review before session: http://www.instructables.com/id/Fun-classic-envelope-prank./
ACTIVITY TYPE 1 **30 MINUTES**	**NEW INFORMATION:** Pass out materials and give step by step directions on how to construct the Snake Eggs. The directions must be given as a whole group and made step by step. Have participants test them out.	
ACTIVITY TYPE 2 **10 MINUTES**	**APPLICATION:** Review how the snake egg system works. Explain Potential and Kinetic Energy. See Instructor Addendum for supporting information.	For each person: Materials for snake eggs and a premade snake egg set • 1 Envelope • 1 rubber band • 1 small paper clip • 1 short piece of sturdy wire (possibly a large paper clip or a piece from a wire coat hanger)
REFLECTION ACTIVITY **10 MINUTES**	**GENERALIZATION:** Have participants write definitions on the outside of their envelopes. **Potential energy: Energy that is stored.** **Kinetic energy: Energy a body has because it is in motion.**	• Pencils

Suggestions for making today's activities more challenging:
Have participants try to create the "Snake Eggs" without directions.

Suggestions for making today's activities less challenging:
Only complete as a demonstration

The following pages include all supporting documents for instructors

Note: Any of these documents could be copied and distributed to youth

ONLINE CURRICULUM RESOURCES

Session 3
Roller Coasters pt. 3
http://www.energyeducation.tx.gov/energy/section_1/topics/potential_and_kinetic_energy/index.html

Session 4
Roller Coasters pt. 4
Background information: http://hyperphysics.phy-astr.gsu.edu/hbase/cf.html

Session 8
Balloon Powered Cars
Introduce Newton's 3rd law.
Background info.:
http://csep10.phys.utk.edu/astr161/lect/history/newton3laws.html

Session 11
Helicopter Design
Directions:http://www.exploratorium.edu/science_explorer/roto-copter.html

Session 13
Structural Engineering
Background info. On this demo:
http://www.wikihow.com/Squeeze-an-Egg-Without-Breaking-It
Additional information:
http://www.teachengineering.org/view_activity.php?url=collection/uaz_/activities/uaz_cardtower_act1/uaz_cardtowers_act1.xml

Session 14
Tower Building
Spaghetti Structure background info:
http://www.rowett.ac.uk/edu_web/Spag_towers_instruct.pdf

Session 15
Pasta Bridge Building pt. 1
Further info:
http://www.cubekc.org/architivities/pasta.html

Session 16
Pasta Bridge Building pt. 2
http://www.cubekc.org/architivities/pasta.html

Session 17
Drought Stoppers
Background info on siphon:
http://www.howstuffworks.com/siphon-info.htm

Session 18
Spinning Science
Background info on top construction
http://spoonful.com/crafts/cd-spinners

Supplementary pt. 2
Snake Eggs
Must view before session:
http://www.instructables.com/id/Fun-classic-envelope-prank./
Explain Potential and Kinetic Energy:
http://www.energyeducation.tx.gov/energy/section_1/topics/potential_and_kinetic_energy/

CURRICULUM PLAN: COMMUNITY STANDARDS

Purpose:	Engage youth in the development of community standards for the group
Time:	15-20 minutes
Materials:	Butcher paper, poster board or flip chart and markers
Planning:	Title your large piece of paper with Junior Engineers. Draw a large circle in the middle of the paper, the inside of this circle will represent the behaviors or expectations the group members want in the group.
Procedure:	Explain to the youth they will be creating their community standards, by defining the behaviors they think are appropriate and inappropriate for their group. Have youth come up and write their ideas for behaviors they want in their group inside the circle (i.e. participate, read, have fun, be respectful, learn something new). If youth identify something they don’t want to happen in their group, they should right this outside of the circle (i.e. fighting, bullying…). After everyone has had the opportunity to add something to the poster, they are agreed upon invite them to sign their name on the poster.
Discussion:	Ask everyone if they know what is means to sign your name on something?
Reflection:	How did it feel to create your own community expectations? Is there anything you think you will have a hard time doing/not doing? What should be the consequence of breaking this contract?

Curriculum Support: Potential and Kinetic Energy

Taken from: http://www.energyeducation.tx.gov/energy/section_1/topics/potential_and_kinetic_energy/
See site for interactive images.

All energy can be in one of two states: potential energy or kinetic energy.

Energy can be transferred from potential to kinetic and between objects.

Potential energy is stored energy - energy ready to go. A lawn mower filled with gasoline, a car on top of a hill, and participants waiting to go home from school are all examples of potential energy.

Gravitational potential energy is the energy possessed by a body because of its elevation (height) relative to a lower elevation, that is, the energy that could be obtained by letting it fall to a lower elevation. For example, water at the top of a waterfall or stored behind a dam at a hydroelectric plant has gravitational potential energy.

Most of the energy under our control is in the form of potential energy. Potential energy can be viewed as motion waiting to happen. When the motion is needed, potential energy can be changed into one of the six forms of kinetic energy.

Kinetic energy is energy at work. A lawn mower cutting grass, a car racing down a hill, and participants running home from school are examples of kinetic energy. So is the light energy emitted by lamps. Even electrical energy is kinetic energy. Whenever we use energy to do work, it is in the kinetic state.

CURRICULUM SUPPORT: CENTRIPETAL FORCE

Taken from: http://hyperphysics.phy-astr.gsu.edu/hbase/cf.html
See website for interactive calculation tools

Centripetal Force

Any motion in a curved path represents accelerated motion, and requires a force directed toward the center of curvature of the path. This force is called the centripetal force which means "center seeking" force. The force has the magnitude.

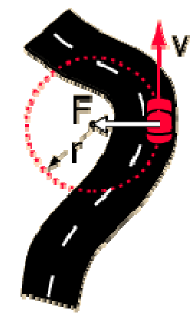
$$F_{centripetal} = m\frac{v^2}{r}$$

Swinging a mass on a string requires string tension, and the mass will travel off in a tangential straight line if the string breaks. The centripetal acceleration can be derived for the case of circular motion since the curved path at any point can be extended to a circle.

Note that the centripetal force is proportional to the square of the velocity, implying that a doubling of speed will require **four times** the centripetal force to keep the motion in a circle. If the centripetal force must be provided by friction alone on a curve, an increase in speed could lead to an unexpected skid if friction is insufficient

$$F_{centripetal} = m\frac{v^2}{r}$$

$\frac{v^2}{r}$ is the centripetal acceleration

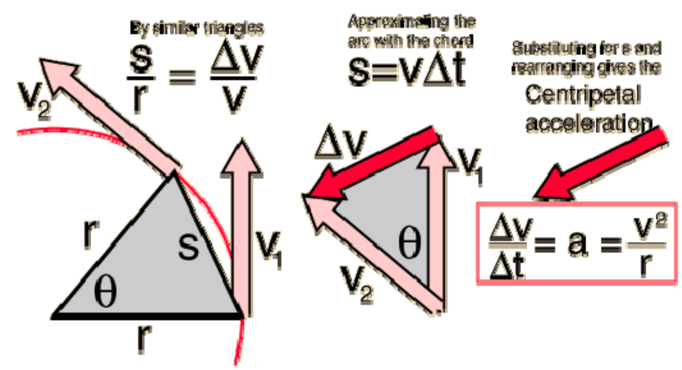


Centripetal Force Calculation

Centripetal force* = *mass* x *velocity*^{2} / *radius

Centripetal Acceleration

The centripetal acceleration expression is obtained from analysis of constant speed circular motion by the use of similar triangles. From the ratio of the sides of the triangles:



CURRICULUM SUPPORT: NEWTON'S THREE LAWS OF MOTION

Taken from: http://csep10.phys.utk.edu/astr161/lect/history/newton3laws.html

Let us begin our explanation of how Newton changed our understanding of the Universe by enumerating his Three Laws of Motion.

Newton's First Law of Motion:
Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

This we recognize as essentially Galileo's concept of inertia, and this is often termed simply the "Law of Inertia".

Newton's Second Law of Motion:
The relationship between an object's mass m, its acceleration a, and the applied force F is $F = ma$. Acceleration and force are vectors (as indicated by their symbols being displayed in slant bold font); in this law the direction of the force vector is the same as the direction of the acceleration vector.

This is the most powerful of Newton's three Laws, because it allows quantitative calculations of dynamics: how do velocities change when forces are applied. Notice the fundamental difference between Newton's 2nd Law and the dynamics of Aristotle: according to Newton, a force causes only a *change in velocity* (an acceleration); it does not maintain the velocity as Aristotle held.

This is sometimes summarized by saying that under Newton, $F = ma$, but under Aristotle $F = mv$, where v is the velocity. Thus, according to Aristotle there is only a velocity if there is a force, but according to Newton an object with a certain velocity maintains that velocity *unless* a force acts on it to cause an acceleration (that is, a change in the velocity). As we have noted earlier in conjunction with the discussion of Galileo, Aristotle's view seems to be more in accord with common sense, but that is because of a failure to appreciate the role played by frictional forces. Once account is taken of *all* forces acting in a given situation it is the dynamics of Galileo and Newton, not of Aristotle, that are found to be in accord with the observations.

Newton's Third Law of Motion:
For every action there is an equal and opposite reaction.

This law is exemplified by what happens if we step off a boat onto the bank of a lake: as we move in the direction of the shore, the boat tends to move in the opposite direction (leaving us facedown in the water, if we aren't careful!).

CURRICULUM SUPPORT: ROTO-COPTER

Taken from: http://www.exploratorium.edu/science_explorer/roto-copter.html

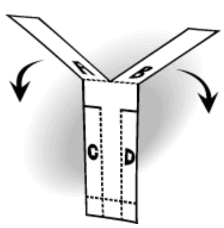
Roto-Copter

This simple paper toy spins through the air like a mini-helicopter

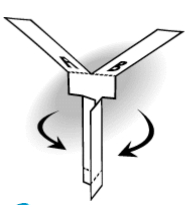
What do I do?

1 Print out the Roto-Copter pattern. Cut along the solid lines only. Fold on the dotted lines.

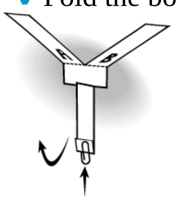
2 Fold A toward you. Fold B away from you.



3 Fold C and D over each other so they overlap.



4 Fold the bottom up and put a paper clip on it.



5 Hold the Roto-Copter by the paper clip. Throw it like a baseball, as high and far as you can. It will spin to the floor. You can also stand on a chair or on the stairs and drop it. Ask a grown-up if you can drop it out the window.

6 If you want, you can use crayons or markers to color your Roto-Copter before you fold it. The colors will blur together when it spins.

ROTO-TARGET

Make three Roto-Copters for each person. Use a marker to draw a 1-foot circle on a piece of newspaper. Put a cereal bowl in the middle of the circle. The circle is the target area and the bowl is the bull's-eye. Take turns standing on a chair at the edge of the newspaper and dropping your Roto-Copters. At the Exploratorium, we get 3 points for a bull's-eye, 2 points for a copter inside the circle, and one point for just hitting the newspaper-but you can make up any rules you want.

Wow! I Didn't Know That!

Igor Sikorsky designed the first successful helicopter in the late 1930s. His inspiration came from drawings of an aircraft with a spinning wing, drawn by Leonardo da Vinci nearly five hundred years before.

Places to Visit

Igor I. Sikorsky Historical Archives -Lots of photographs and information about helicopters and the man who invented them.

Leonardo da Vinci Museum
-This online gallery displays images and other information related to Leonardo da Vinci. The "West Wing" of the gallery has images of helicopters and other flying machines.

This and dozens of other cool activities are included in the Exploratorium's Science Explorer books, available for purchase from our online store.

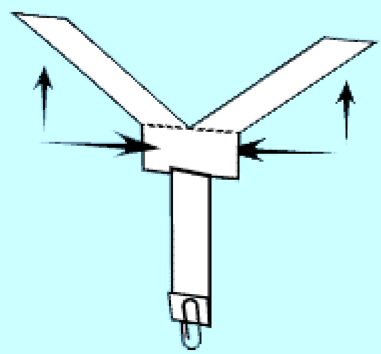
We would like to hear about your results and discoveries. Please send an email message to Ken Finn.

What's Going On?

Why does the Roto-Copter spin?

When the Roto-Copter falls, air pushes up against the blades, bending them up just a little. When air pushes upward on the slanted blade, some of that thrust becomes a sideways, or horizontal, push.

Why doesn't the copter simply move sideways through the air? That's because there are two blades, each getting the same push, but in opposite directions. The two opposing thrusts work together to cause the toy to spin.



Next time you drop your copter, notice which direction it spins as it falls. Is it clockwise or counterclockwise? Now bend the blades in opposite directions-if blade A was bent toward you and blade B was bent away, bend B toward you and A away. Drop the copter again. Now which way does it spin?

In the Spinning Blimp, air pushes up on the flat sides of the strip of paper. When the flat side of the paper strip is parallel to the ground, the blimp drifts down like a flat piece of paper. But if the blimp tilts so that the flat side of the strip is at an angle to the ground, the paper strip gets a sideways push, just like the blade of the copter, sending the blimp spinning. Each time the flat strip comes around, it gets another push and goes for another spin.

CURRICULUM SUPPORT: SQUEEZING AN EGG

Taken from: http://www.wikihow.com/Squeeze-an-Egg-Without-Breaking-It

How to Squeeze an Egg Without Breaking It
Is it possible to squeeze an egg as hard as you can without breaking it? The answer is - yes! We've all learned the hard (and messy) way that eggs can be fragile, but despite their reputation, eggs are amazingly strong. Amaze your friends and yourself by doing this easy experiment.

- Eggs are similar in shape to a 3-dimensional arch, one of the strongest architectural forms. The curved form of the shell distributes pressure evenly all over the shell rather than concentrating it at any one point.
- By completely surrounding the egg with your hand, the pressure you apply by squeezing is distributed evenly all over the egg. However, eggs do not stand up well to uneven forces which is why they crack easily on the side of a bowl.

One Hand Method:


Step 1: Place an egg on your fingers


Step 2: Close your hand so that your fingers are completely wrapped around the egg.


Step 3: Squeeze the egg by applying even pressure all around the shell.


Step 4: Look at everyone's amazement (mostly your own) as the egg remains whole and your hands remain dry!

Two Hand Method:


Step 1: Lace your fingers together

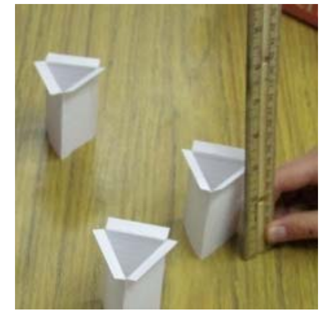

Step 2: Place the egg lengthwise between your palms


Step 3: Squeeze your palms together as hard as you can on the points of the egg.

CURRICULUM SUPPORT: STRUCTURAL TOWERS

Taken from: http://www.teachengineering.org/view_activity.php?url=collection/uaz_/activities/uaz_cardtower_act1/uaz_cardtowers_act1.xml

Index Card Towers



Structural engineers design boats, airplanes, office buildings, football stadiums, the tallest buildings in the world—the list goes on! Even your desk and the chair you are sitting in were designed by structural engineers. Every structure must be designed to meet specifications that ensure it serves its function correctly and without failure. Your chair must be designed to not break when you sit in it and also to not sag. Imagine if your chair sunk down 3-4 inches when you sat down in it. You would have a hard time reaching your desk! So, we see that structures must be designed for strength and deflection to be fully functional. Buildings are the same. If the floor sagged as you walked across it, you would get dizzy or if the building swayed too much in the wind you might become ill. These are all important considerations when we design for deflection. Structural engineers must also be certain that buildings have the strength to stand up. A parking garage must have the strength to resist a lot full of cars pulling down on it and an office building must be able to remain standing in an earthquake. Can you think of any other important things that structural engineers should consider in their designs? (Possible answers: Stability, so cars do not flip over; torsional strength, so shafts resist twisting; temperature, so roads do not crack from extreme temperatures.)

Engineers use a variety of materials and systems to meet the strength and deflections specifications that are required. Wood, concrete and steel are three of the most common and important materials available. You have probably seen bridges built from steel, such as the Golden Gate Bridge, and bridges built from concrete, such as highway overpasses. Structures built from concrete often have steel embedded within the concrete to combine the properties of the two materials. Skyscrapers are also built from different materials. Most skyscrapers in the U.S. are built with steel infrastructures, but the tallest building in the world, Burj Khalifa, uses concrete reinforced with steel. What do you think your house is made from? (Possible answers: Brick, wood, steel and/or concrete.) Why would engineers choose different materials? (Possible answers: Strength, climate conditions, availability, price.)

The structural composition of every building is as important as the material used to build it. Engineers must decide on the forms and shapes they design and build

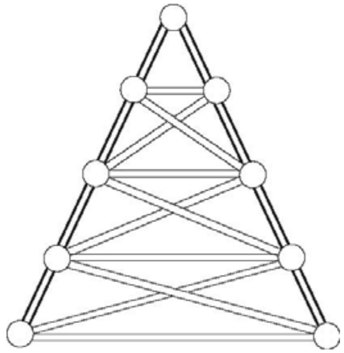
with, such as triangles, circles or rectangles. For bridges, we may use a suspension bridge, a cable-stayed bridge, or a truss system. For a 10-story office building, we may use a moment frame or braced frame. We can see from ancient buildings that the basic choice of shape has fascinated builders for centuries. Think of the triangular Egyptian pyramids, rectangular Grecian temples, circular Roman Pantheon, and parabolic Gothic Cathedrals. Modern builders build with "I" beams. What shape do you think could best support an elephant over a canyon? What shape do you think would be good at not tipping over in the wind? (Points to make: Corners create stress concentrations that lead to weakness and circles have no corners. Also, the wider a shape or the more material at its perimeter, the stronger the shape may be—such as an "I" beam.)

Index Card Towers: Vocabulary/Definitions

concrete: A material composed of cement and an aggregate such as sand, gravel or crushed stone.
frame: A structure composed of beams and columns that provide a building with strength and stiffness.
infrastructure: The part of the building that supplies the building strength and stiffness.
"I" beam: A structural beam or column in the shape of an I, usually made of steel but sometimes other materials, such as wood.

CURRICULUM SUPPORT: SPAGHETTI STRUCTURES

Taken from: http://www.rowett.ac.uk/edu_web/Spag_towers_instruct.pdf



SPAGHETTI TOWER

TIME ALLOWED:
30 minutes

OBJECTIVE:
To construct a tower as high as possible using spaghetti and marshmallows. Limited supplies of materials are available. Pieces of spaghetti may be broken into desired lengths.

MATERIALS: Spaghetti (c. 50g/team)Mini marshmallows (c. 25g/team)

TEAM SIZE: Suggested team size is three

RULES:
Only the materials provided may be used. The highest tower at the end of the day will be the winner.
The judge's decision in all matters is final!

BUILDING HINTS AND TIPS
There are many ways of building towers using spaghetti and marshmallows. These notes are intended not as instructions, rather as points to think about in developing the design.

1. Make sketches of any good ideas you have and make plans for how you will construct the tower - good planning and design are essential to building a successful tower!
2. Where you choose to use shortened pieces of spaghetti, make sure you cut them accurately. If you don't use pieces of equal length in a particular section of the tower, it may start to twist and topple.
3. Use shorter pieces of spaghetti or put in braces (triangular supports) to help support squares or rectangles in your tower.
4. Think carefully about whether the spaghetti should pass all the way through the marshmallow, or not.. Remember that the strength of a joint is dependent on how well the marshmallow can 'grip' the spaghetti strand without it slipping.
5. There will be most stress at the base of the tower - think about how to add strength here.
6. THE BUILDING MATERIALS. Although spaghetti and marshmallows don't seem like strong building materials, you can build surprisingly elegant and sturdy structures using them. The spaghetti provides the framework and support for the tower, the mini-marshmallows are used to make connectors. The important thing to realize is that the marshmallows "grip" onto the pieces of spaghetti to hold the joints in place. The

strength of a joint is dependent on how well the marshmallow can hold the spaghetti strands without them slipping. If there is a heavy load (weight) on the joint it may cause the marshmallow to "creep" or change shape until the joint fails this is most likely to happen where the load is the greatest, i.e. at the bottom of the tower.

7. MAKING STRONG SHAPES. The shapes that are used to build strong structures are very important. Think about the shapes that have been used to construct bridges and towers that you have seen or know about. Start to practice building with spaghetti and marshmallows by testing out different basic shapes such as squares and triangles. You will discover that squares collapse easily under compression. Four pieces of spaghetti joined in a square give way at their joints the weakest points. But, if you make a spaghetti triangle, the situation changes. To make the triangle collapse you have to push very hard. You can build very large structures from squares and cubes, but they will be weak and will usually fall down quite easily. If you try to make a structure out of triangles and pyramids, it will be strong but you will use a lot of materials before the tower gets very tall! The best way to build a tall tower is to use both triangles and squares - that way you can build big structures that are less wobbly. A diagonal piece of spaghetti put across a square turns a square into two triangles and makes it more rigid.
8. COMPRESSION AND TENSION - SOME BASIC PRINCIPLES. Even though a tower you build may be standing perfectly still, the individual parts are always pushing and pulling on each other. Large structures remain standing because some parts are being pulled or stretched (tension members) at the same time as others are being pushed or squashed (compression members). The vertical pieces of spaghetti in your tower will be in compression, and the compression will be greatest at the base of the tower. The horizontal and diagonal pieces of spaghetti in the tower may be in tension. The strength of these tension members will not depend on how strong the spaghetti is, but on how well the marshmallows can grip it (and hold it in place). The marshmallows are most likely to change shape and fail at the bottom of the tower, where there is most weight on them (from the compression and tension members).

CURRICULUM SUPPORT: PASTA BRIDGES

Taken from: http://www.educationworld.com/a_session/02/lp275-05.shtml

This activity idea, from Nancy Anderson and implemented by Julia Shahid, was presented at archiCamp, Seaside, 1996.
The participant will: learn about the elements of architecture involved in bridge building, practice problem solving in a hands-on cooperative group effort, work in groups of three or four, design a bridge using pasta that fulfills the requirements below.

Requirements:

- Use given materials economically.
- Hold a load of 4 inches at mid-span.
- Is self-supporting.
- Clear span 12 inches.
- Looks like a bridge.

Participants will be given basic resources as they begin their project. If they need more supplies, they may purchase extra. This eliminates the wasting of the pasta and glue. It makes participants aware that an architect begins with a certain budget for constructing bridges and they must try to work within their budget. However, it is sometimes necessary to spend more than they anticipated.

Participants will begin with:

- Spaghetti - not thick variety - 1 inch diameter circle
- 1/2 cup dry rigatoni
- 1/2 cup bow pasta
- 2 sheets of lasagna noodles
- 1 spool of thread
- 1 glue gun (low temp hot melt)
- 5 glue sticks for glue gun
- And 200 points

Most spaghetti is 9-10 inches long, so participants need to splice in order to span 12 inches. They must realize that the ends of the bridge need to be as strong as the part spanning the 12 inches. They need to realize that the lasagna snaps easily if used flat, however the lasagna standing on its side will support 4 pounds by itself.

The purchase price for additional supplies:

- 1 inch bundle of spaghetti - 10 points
- 1 spool of thread - 25 points
- 1/2 c. swirls - 5 points
- 1 sheet lasagna - 5 points
- 1 glue stick - 10 points
- 1/2 c. rigatoni - 5 points
- 1/2 c. bows - 5 points

Academic Objectives:

Demonstrate understanding of beam action and ability to understand forces acting on a beam and modify design to counteract observed behaviors.
Be able to develop complete list of criteria for evaluation, as well as, experience and benefit from team interaction.

CURRICULUM SUPPORT: PASTA BRIDGES

Taken from: http://www.howstuffworks.com/siphon-info.htm

A Siphon

Siphon, a bent tube used to move a liquid over an obstruction to a lower level without pumping. A siphon is most commonly used to remove a liquid from its container. The siphon tube is bent over the edge of the container, one end in the liquid and the other outside end at a lower level than the surface of the liquid in the container. If the tube is once filled, a flow of liquid from the container through the tube will be set up. Several methods can be used to fill the tube. A small pump may be used. (The pump is no longer necessary once the flow has begun.) Water or any other harmless liquid may easily be siphoned through a small, short tube by sucking it through the tube with the mouth, as through a drinking straw, until the flow is started. The tube may also be filled by submerging it completely and then covering both ends while it is placed in position.

Siphons are sometimes used in irrigation to lift water from the irrigation canal, over a dike, and into a field. Wine may be siphoned from the top of large winemaking vats without disturbing the sediments on the bottom. Aqueducts sometimes act as siphons in carrying water over elevations.

How a Siphon Works

Siphons operate by atmospheric pressure. The container from which the liquid is siphoned must therefore be open to the air. When the tube is filled, the liquid will run out of the lower end. (The greater weight of the liquid in the arm outside the container determines the direction of flow of the liquid.) As the liquid starts to flow, the fluid pressure at the top of the tube is lowered. A liquid always flows from an area under higher pressure to an area of lower pressure. The liquid in the container (under atmospheric pressure) flows up into the tube (an area of lowered pressure). This liquid in turn will flow out the outside end of the tube, again lowering the pressure at the top of the tube.

Once the flow has begun, it will continue if undisturbed as long as the inside end of the tube remains below the surface of the liquid. The flow can be cut off by raising the outside end of the tube above the level of the surface of the liquid in the container.

One limit to the use of siphons is imposed by the height to which atmospheric pressure can lift a given liquid. At sea level, atmospheric pressure can raise water to a height of about 30 feet (9 m). At higher altitudes the pressure is less, as is the height to which the water can be raised. Liquids heavier than water cannot be raised as high as water. Thus at sea level, mercury can only be raised about 30 inches (760 mm).

CURRICULUM SUPPORT: CD SPINNERS

Taken from: http://spoonful.com/crafts/cd-spinners

What you'll need:

- Old CD
- Large shooter marble
- Glue, glue stick, or hot glue
- Design templates
- Markers
- Scissors
- Plastic bottle cap

How to make it:

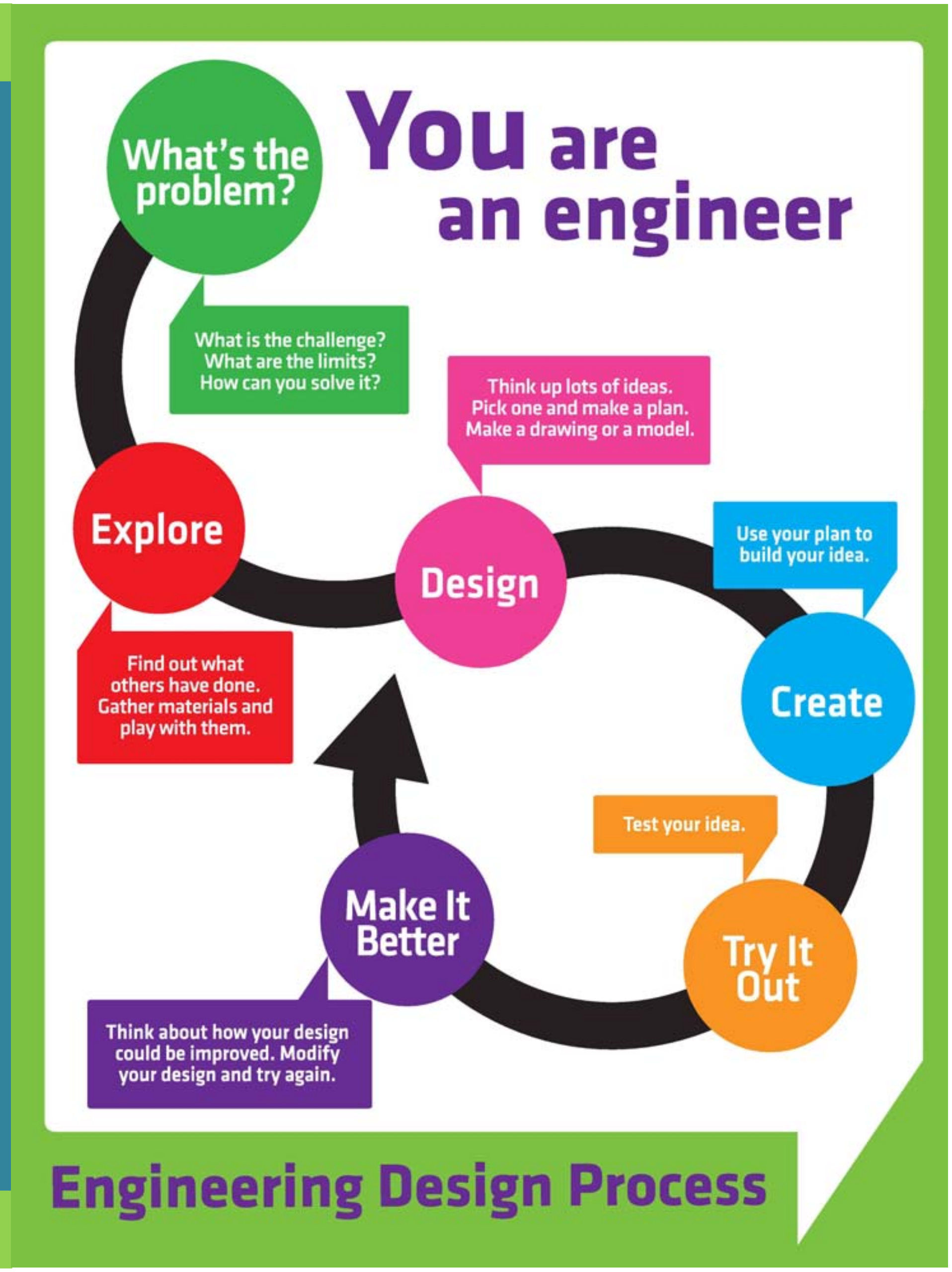
For each top, set a large shooter marble into the hole of an old CD, securing it with a generous amount of glue. We used Crafter's Pick The Ultimate, which works well for joining nonporous materials, but you can use hot glue for quicker results.

To re-create our top designs, print out the templates, color them in with markers, and cut them out (cut out the center holes too). Flip over the CD and adhere the template to it with glue or a glue stick.

For the handle, attach a plastic bottle cap to the center of the CD with Ultimate glue or hot glue. If you use Ultimate glue, let it dry overnight before taking your top for a spin.

The following pages include all printed supplementary youth participant materials.

JUNIOR ENGINEER DISCOVERY LOG



Name:

Junior Engineer Discovery Log: Session 1

Diagram one of your rollercoaster tracks below:

Describe one way you changed your track and explain how it affected the roll of the marble:

____

____

____

Junior Engineer Discovery Log: Session 2

Investigative Questions:

Prediction:

Steps:

Data Chart:

Start Height	Try 1 Time sec.	Try 2 Time sec.	Try 3 Time sec.	Avg. Time sec.
20 cm				
40 cm				
60 cm				
80 cm				

Claim:

JUNIOR ENGINEER DISCOVERY LOG: SESSION 3

Diagram the slowest roller coaster below:

Time to go down the track___________ sec.

Junior Engineer Discovery Log: Session 4

Diagram the loop roller coaster below:

Which works better, big loops or small loops? Why?

____

____

____

JUNIOR ENGINEER DISCOVERY LOG: SESSION 5

List ways a car could be powered:

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____

What was the average distance the cars rolled today: _______________ meters

JUNIOR ENGINEER DISCOVERY LOG: SESSION 6 – IMPROVED SAIL DESIGN

Draw a diagram of your design below:

Class Average___________________m

JUNIOR ENGINEER DISCOVERY LOG: SESSION 7

Investigative Questions:

Prediction:

Steps:

Data Chart:

Num. of winds	Try 1 (cm)	Try 2 (cm	Try 3 (cm)	Avg. (cm)
10				
20				
30				
40				

Claim:

Junior Engineer Discovery Log: Session 8

Investigative Questions:

Prediction:

Steps:

Data Chart:

Circumference of Balloon	Distance Traveled (cm)

Claim:

Junior Engineer Discovery Log: Session 9

Diagram the tablet and the water in the bag:

What do you think happened?

Diagram a rocket and label the parts:

Nose cone

Body

Fins

JUNIOR ENGINEER DISCOVERY LOG: SESSION 10

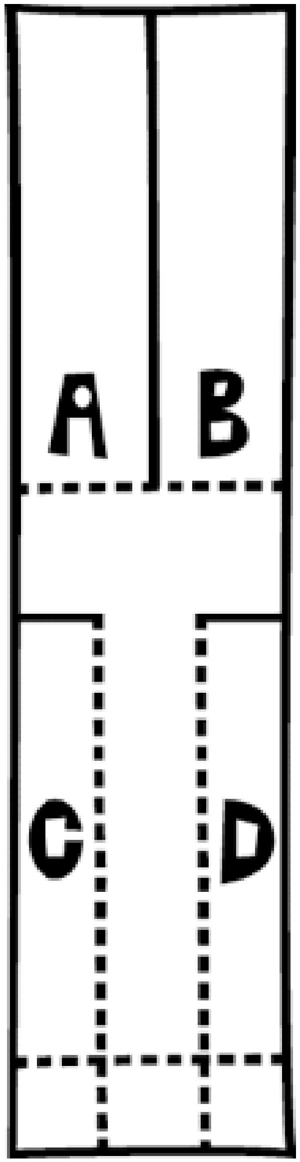
Investigative question:

Data:

Tablet Size	**Launch Height (meters)**
1/4	
1/2	
3/4	

Claim:

Roto-Copter Pattern to Cut Out



JUNIOR ENGINEER DISCOVERY LOG: SESSION 11

Investigative question:

Place a check mark in each box under the copter that hit the ground first.

1 clip	3 clips

2 clips	4 clips

1 clip	4 clips

Did you notice any pattern on the copters that hit the ground first? Was it the one with the most clips or the least?

Why do you think it turned out this way?

JUNIOR ENGINEER DISCOVERY LOG: SESSION 12

Improved parachute design. Design a parachute that will take the longest amount of time to hit the ground. Draw your design below.

JUNIOR ENGINEER DISCOVERY LOG: SESSION 13

Draw a picture of your support design before you construct it.

How many books did it support _______________.

Junior Engineer Discovery Log: Session 14

Draw a diagram of your spaghetti structure before you construct it.

Height of Structure __________ m.

Name_____________________________

JUNIOR ENGINEER DISCOVERY LOG: SESSION 16

Weight supported by bridge: ____________

What do you think was a good design part of your bridge?

What would you do next time to make it stronger?

JUNIOR ENGINEER DISCOVERY LOG: SESSION 17

Draw a diagram of your drought stopper below:

JUNIOR ENGINEER DISCOVERY LOG: SESSION 18

Time of spinning top with now weights___________

Design #1 Draw below

Spin time________

Design #2 Draw below

Spin time __________

JUNIOR ENGINEER DISCOVERY LOG: SESSION 19

Draw design improvement #1

Draw design Improvement #2