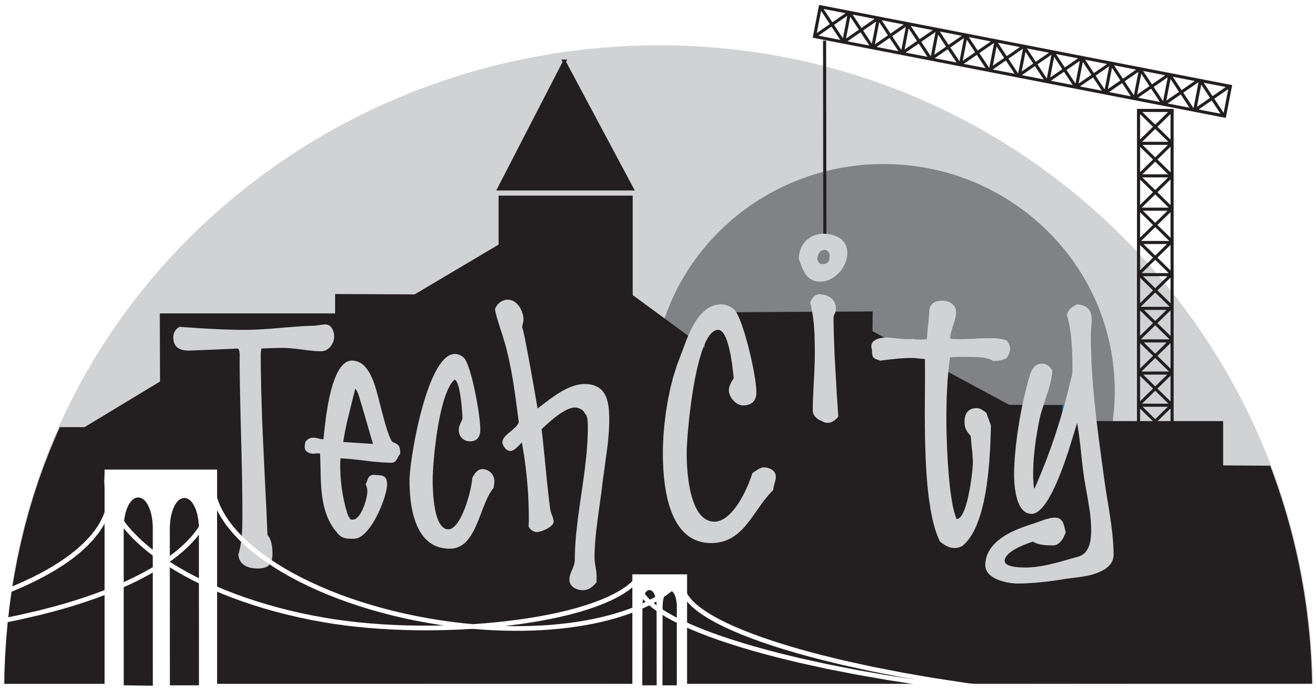

School Group Pre/Post-Visit Guide

Sciencenter

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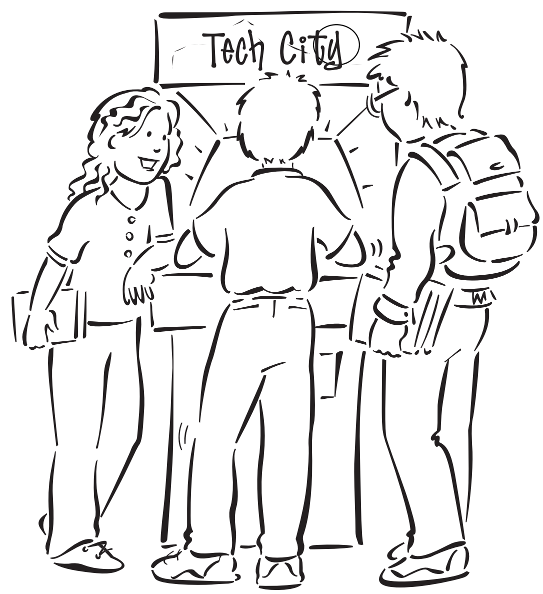
Visiting "Tech City"

Thank you for visiting "Tech City"on your field trip! The exhibits have been designed to address the human needs of those who inhabit a typical small city. As you explore the exhibition you learn how the varied challenges of a city are met and solved by the engineering process. Visitors help build a bridge, tile the city plaza, choose a lighting system, control floods, and design a menu.
In this way, engineering is presented as a problem-solving process which balances goals with constraints.



Engineering is a dynamic field of inventing, designing, building, and testing. The exhibition helps bring this excitement to you and your students so that engineering can be considered a viable career alternative for all, including women and underrepresented groups.

You can use the following questions as a starting place to help your students think about the engineering process as they explore the exhibits or as you work on the suggested activities in your classroom.

- Did your structure work the way it was designed?
- Did your design meet the goal(s)?
- How could you change your design to make it more effective?
- What other materials would you have liked to use?
- Which designs were most successful?
- How did your group decide on the final design?
- What other observations did you make?
- Were there any unexpected results?
- What were the difficulties?
- If you were to try this again, what would you do differently?
- How do you think additions or changes to the original design would affect the results?

Pre- and Post-Visit Activities

When your class visits "Tech City" you and your students learn that engineering is about more than just math and computers. Engineers imagine new things and design them. They build things. They test them. They figure out how to make things better. They solve problems. An engineer sets a goal and works to achieve that goal. Often there are constraints (limits) on the engineer's time, budget, space, or materials.

The following are provided as extension activities about the engineering process and concepts for your classroom use before or after a visit to the "Tech City" exhibition. Students will be able to go through the process of inventing, designing, building, and testing to reach the goals they set, while keeping in mind the constraints that may limit them.

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These activities are designed for use by students in grades 3 through 8 and their teachers. We recognize that modifications may need to be made to some of the activities to make them more suitable for your particular class.

To support the National Science Education Standards, these activities emphasize inquiry-based experiences for your students by focusing more on student-directed learning rather than teacher-directed instruction; process-oriented learning rather than individual student work; problem solving and integration across subjects rather than knowing specific content; group interactions and science for all rather than science for a few high achievers. We hope that they will serve your classroom in this capacity.

Inventing

Necessity's Daughter

To help think of inventive ideas, have students work individually or with partners to make a list of 20 verbs and a list of 20 nouns. Then pair up the words. Someone years ago may have paired up "drying" and "hair" and invented the hair dryer! What might your students invent?

Goal:
Create a list of ideas to invent.

Constraints:
Your only limit is your imagination!

Smart Art

Engineers use models to develop their designs before building them on a larger scale. Models are an important part of the design process because they create a visual representation of the structure or invention for the engineers and for others with whom they may be working.

Goal:
Create a poster that demonstrates how your invention might work.

Constraints:
You may only use the materials provided.

Teams of students can use their ideas from "Necessity's Daughter" to create a three-dimensional poster model detailing their invention. Or they can design a Rube Goldberg™ device. (Rube Goldberg was a cartoonist in the first half of the twentieth century who created very elaborate drawings of machines that did very simple things.) You can find examples of Rube Goldberg's work on the web at www.rubegoldberg.com.

Materials

Poster board (1 per student or group)

Pencils (1 per student)

Scissors (1 pair per student or group)

Glue (1 bottle per student or group)

Masking and transparent tape (1 roll of each per group)

Building supplies: straws, pipe cleaners, paper, cotton balls, string, paper cups, pieces of foam, plastic, foil, paper towel tubes, craft sticks, rubber tubing, etc.

Paint (optional)

Markers (optional)

Instructions

Use the **materials on hand** to design and **build a 3-D poster model** of your invention. Parts can move to show how they might work.

Or **design a Rube Goldberg™ device** on your poster. Could you make toast in twenty steps or more? Try your hand at this fun way to design.

Questions for discussion

How does your invention work? What does it do?

How do the materials you used represent other things? (For example, what does a pipe cleaner represent?)

Could someone build this invention from your design?

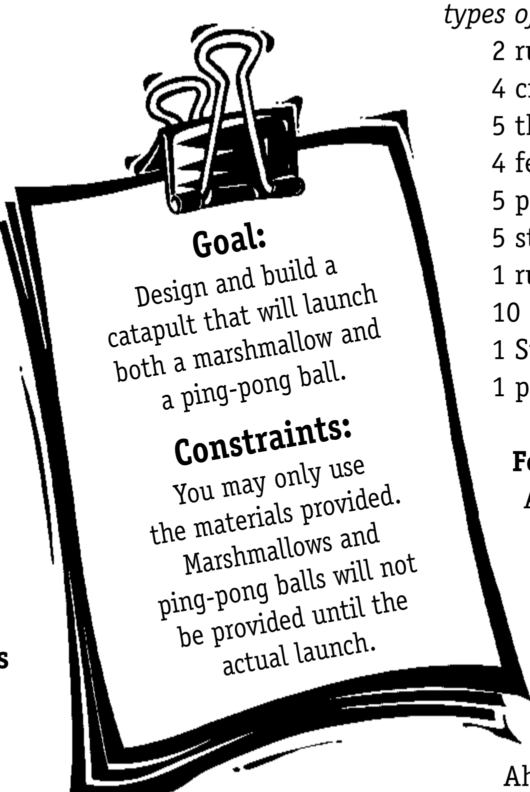
How could you change your design to improve it?

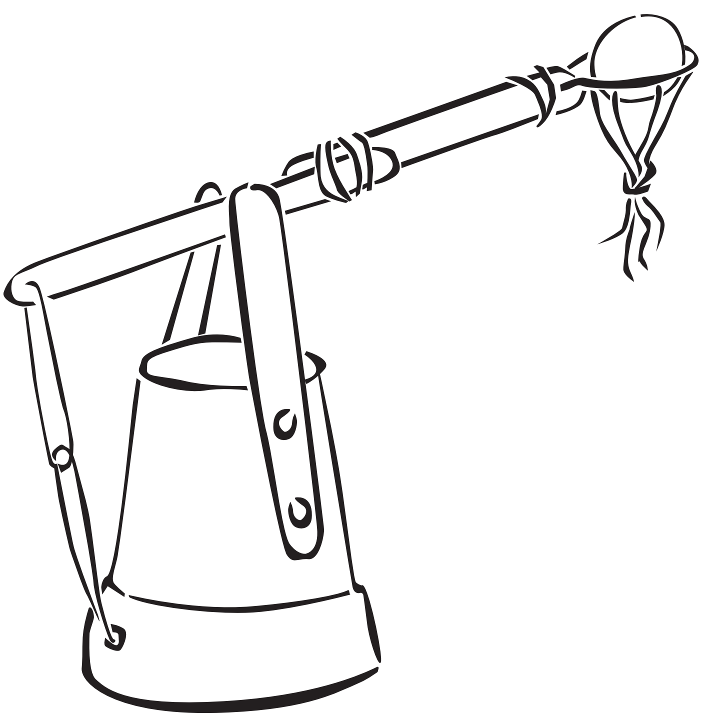
How did your group come up with the idea?

Building

Can you Catapult?

Students will work together to design and build a device that will launch a marshmallow and a ping-pong ball. Distances will be measured in order to graph them and average them. Since a marshmallow is not aerodynamic, students will need to be very careful in the design process.





Materials

For each team of 2 – 3 students *(Make sure sizes and types of materials are the same across the groups.)*:

- 2 rubber bands
- 4 craft sticks
- 5 thumb tacks
- 4 feet of string
- 5 paper clips
- 5 straight pins
- 1 rubber eraser
- 10 straws
- 1 Styrofoam or plastic cup
- 1 pair of scissors

For the launch:

- A book or box to act as launching pad
- Measuring tape
- 1 bag of large marshmallows
- 1 – 2 ping-pong balls
- Graph paper

Instructions

Ahead of time, divide the materials into packets. You may also want to discuss different types of launchers like catapults, levers, and slingshots.

Hand out the packets of materials to each group and allow students time to **plan their designs, build them, and test them**. Make sure the students know that they can **only use the materials given**. They can use the scissors to cut the materials, but they cannot be a part of the launcher.

At the launch, have teams place their structures on the launch pad one at a time. Each team should be allowed 2 launches of the ping-pong ball and 2 launches of the marshmallow. Best results can be recorded for the graphs and the averages.

Discuss the results with the class.

Questions for discussion

Did your structure work the way it was designed?

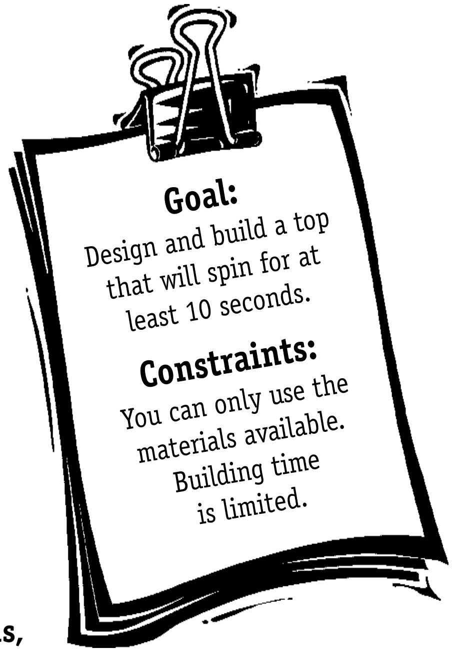
How did your group decide on the final design?

How would you change your design to make it more effective?

Were you surprised by the results?

What other materials would you have liked to use?

You're the Tops!



An engineer, working specifically with product design, tests out materials, finds out how the product should work, and designs, tests, and re-designs the product until it does exactly what it is meant to do.

Students will learn what makes a top spin and will use what they learn to design and build a spinning top using everyday household materials. Students should work in teams to design their tops so that they spin for at least 10 seconds. This activity can be extended if time permits.

Materials

Pointed scissors (or nail)

Variety of wooden/plastic ready-made tops

6-inch and 9-inch diameter plastic plates (10 per team)

Plastic lids from margarine tubs and coffee cans (small and large) (10 per team)

8-inch and 16-inch diameter cardboard circles (10 per team)

Metal washers (10 per team)

Wooden spools (2 per team)

Ribbon or yarn (2 spools or skeins)

Masking tape (2 – 3 rolls)

Sharpened pencils (1 – 2 per team)

Stopwatch or watch with a seconds' hand

Other materials that can be converted into tops: a Frisbee, a large pizza pan, a sponge-rubber ball, Tinker toy parts, tuna can, margarine tub

Instructions

Before the activity, teachers may want to put small holes in the center of the plates and lids to make it easier for students to begin. Pointed scissors or possibly a nail may be needed to do this.

Have students experiment first with the ready-made tops to understand how they spin and what designs work best in achieving the goal.

Using the pencils and a stack of 5 – 10 plates, direct students to explore how the tops spin best. Have them try positioning the plates near the top and the bottom of the pencil. Experiment with the number of plates and the distribution of the weight. (Students can also be given washers to tape to the plates to vary the weight distribution.)

Once students have determined which design works best, they can gather other **materials (plastic lids or cardboard, wooden spools, etc.)** and build a top. **Building time** can be **limited to 15 minutes**.

Test the tops and see **how many meet the goal**. Discuss the results. (Optional extensions: Graph the spinning times. Put paper underneath the tops to see what designs the pencils make. Use colored pencils, markers, or pens if desired.)

If time permits, allow students to re-design and re-test their tops. They can use stickers to help observe rates of spin. They can experiment with methods of release (using hands, using string to wrap around, etc.).

Questions for discussion

Did your design meet the goal?

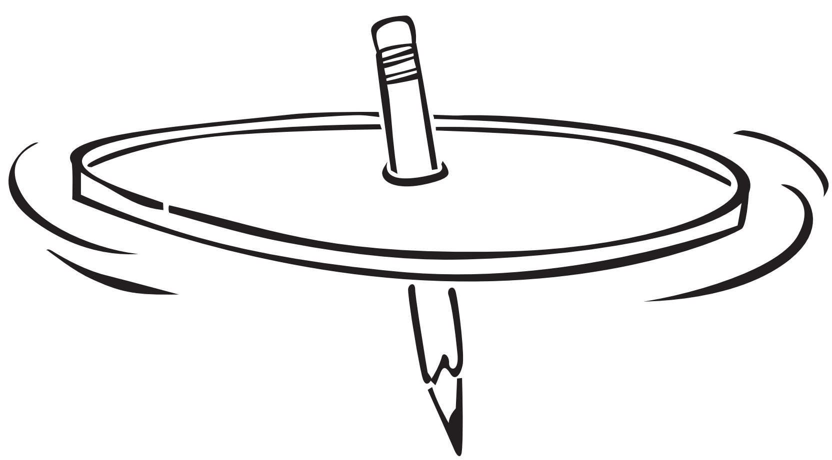
How would you change the design if you could?

Which designs spin longest?

How does size affect spinning time?

What other observations did you make?

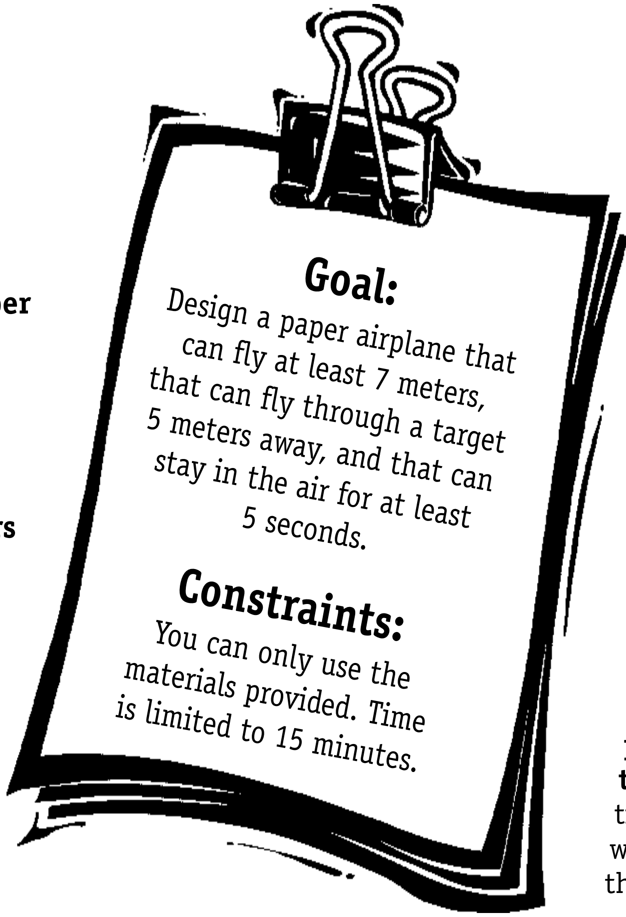
Were there any unexpected results?



Designing

Plane and Simple

Students design a paper airplane that can be tested for distance traveled, accuracy in hitting a target, and time spent in the air. Aeronautical engineers would need help from electrical engineers and mechanical engineers to design their planes to work this way. They would also have to factor in the safety of those on-board and countless other details. For these simpler designs, your students can work on their own or in teams. (Teams will allow for sharing of ideas and efficient use of building and experimenting time.)



Materials

Copy paper (5 pieces per student or team)

Transparent tape (1 – 2 rolls per student or team)

Rulers (1 per student or team)

Scissors (1 pair per student or team)

Measuring tape (2 – 3 per class)

Masking tape (1 roll per class)

Hula-hoop or other target to hang

Stopwatch

Paper and pencil to record results

Instructions

Set up the testing site: Hang up the target and mark a launching spot with masking tape that is 5 meters away.

Clear a path or find a long hallway or outdoor field for the distance test.

If possible, a high place would be ideal for the duration test since airplanes will fly longer if they start from an elevated location.

Students have 15 minutes to design and test a paper airplane design. Give each student or team **5 pieces of paper** and access to tape, rulers, and scissors.

Once the **15-minute building time** is finished, have students choose **one plane** that will be used for **all 3 flight tests**. Each plane should be thrown 3 times for each test. Decide beforehand whether you will record the best result or the average of each of the 3 flights.

Conduct the flight tests and discuss the results with the students.

Questions for discussion

Did your design meet its goals?

How would you change your design if you could?

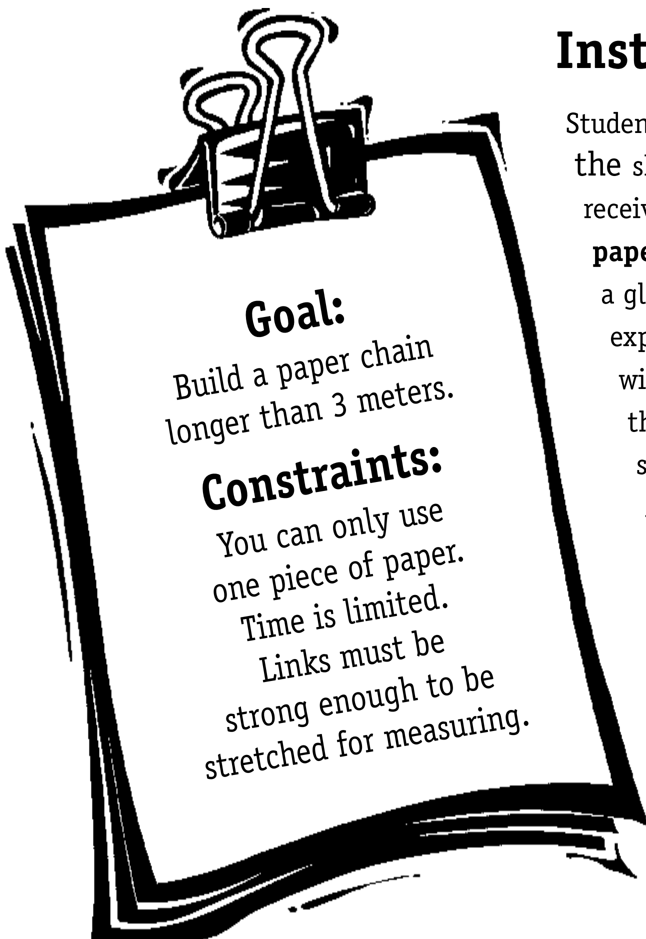
Which designs were most successful at which tests?

Was there a design that did well at all three?

Testing

Links to Length

Engineers must understand how the materials they choose will work for certain jobs. In this simple activity, students will create a paper chain from one piece of paper in order to experiment with the properties of chosen materials.



Materials

Construction paper (1 piece per team)

Scissors (2 pairs per team)

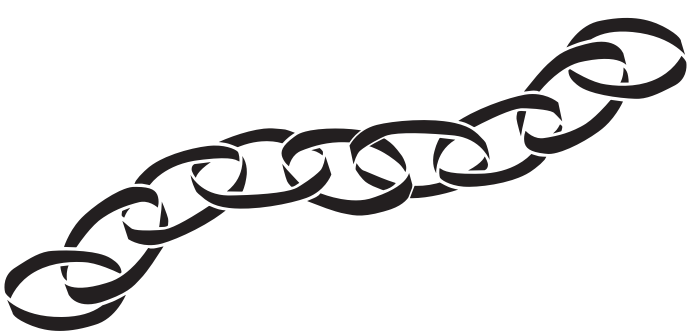
Tape or glue sticks (1 dispenser per team)

Meter sticks/measuring tape (3 per class)

Instructions

Students can work in pairs to promote the sharing of ideas. Each team will receive **one piece of construction paper**, a pair of scissors, and tape or a glue stick. They should first experiment with the length and width of their links to make sure they will be strong enough to be stretched out for measuring. After they have decided on a strategy, they can make their chain. **Building time should be no longer than 10 minutes.**

Once the chains are completed, measure each one to make sure the teams have fulfilled their goals while working under the specified constraints. If time permits, you can make a graph of the number of links or the lengths of the chains. You can also let students try the activity again and compare results.



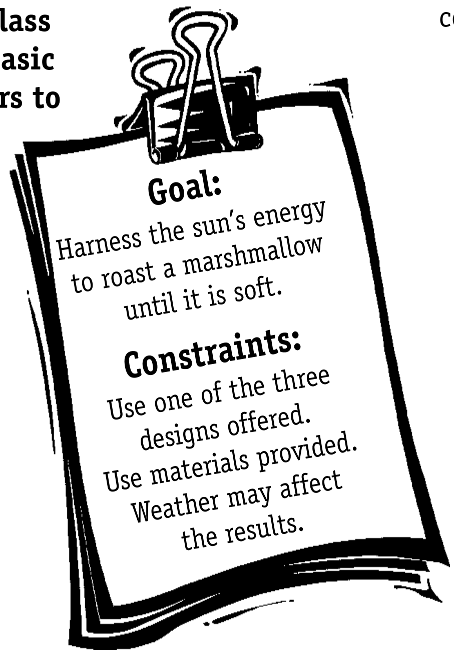
Questions for discussion

Which factors were most important in building your chain (width, length of links, etc.)?

If you were to try this again, what would you do differently?

Roasting Race

In this activity, your class will be able to test 3 basic designs of solar cookers to discover which design is the most effective for roasting a marshmallow.



Materials

Design 1

Empty mixing bowl (3 – 4) — try different materials like metal, wood, or ceramics, or different sizes

Design 2

Flexible piece of card board about 20cm by 36cm — back of legal pad works well (3 – 4)

Piece of string 1 meter long (3 – 4)

Design 3

Empty round oatmeal container with lid (3 – 4)

For All 3 Designs

Aluminum foil (3 – 4 rolls)

Large marshmallows (2 bags)

Scissors (1 pair per team)

Long forks or long, pointed sticks (9)

Clock/stopwatch to keep track of time

A sunny spot to hold the race

Optional Materials

Extra cardboard

Glue/tape

Black construction paper or paint

Instructions

Divide students into teams so they can build their solar cookers together. Each team should **choose one design** and get the materials they need for it. Each of the designs can be modified or changed by the students in order to experiment.

Design 1

Cover the inside of the mixing bowl with aluminum foil *shiny side up*.

Design 2

Cover one side of the cardboard with aluminum foil *shiny side up*.

Bend the long sides of the cardboard into a semi-circle with the foil on the inside of the curve.

Tie the cardboard into this position by wrapping the string around twice and knotting it in the back.

Design 3

Cut a long window in the side of the oatmeal container. Line the inside of the container with aluminum foil, *shiny side showing*.

Have the roasting race!

Set the cookers in a bright, sunny spot with the sun falling directly on the foil. Give each team a stick and a marshmallow and start. **Warn students to be careful not to look at the glaring spots on the cookers!** Keep track of the time it takes each cooker to roast the marshmallow until it is soft. After everyone is done, discuss the results.

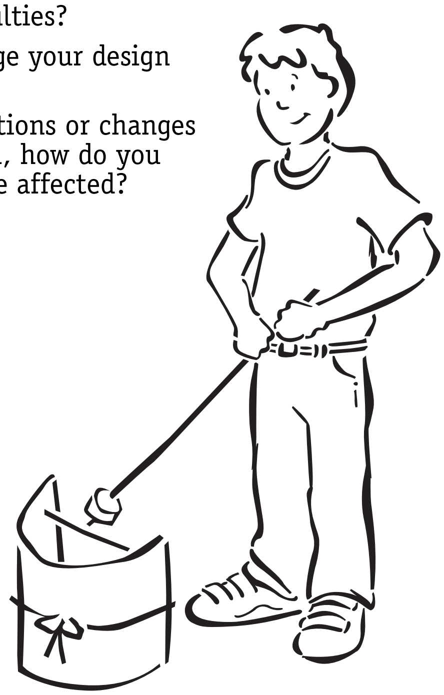
Questions for discussion

Which designs seemed to work fastest? Why do you think they worked so well?

What were the difficulties?

How would you change your design next time?

If you made any additions or changes to the original design, how do you think the results were affected?



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www.rubegoldberg.com
This website contains information about the cartoonist and his work.

www.techcityexhibition.org
Developed in conjunction with the "Tech City" exhibition, this site contains information about engineering and has links to related sites.