Classroom Activities Grades 2-8

National Engineers Week

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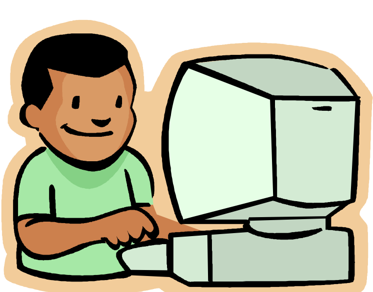


LOCKHEED MARTIN

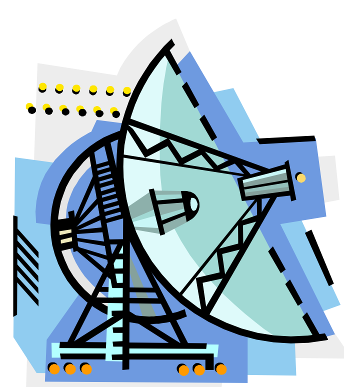
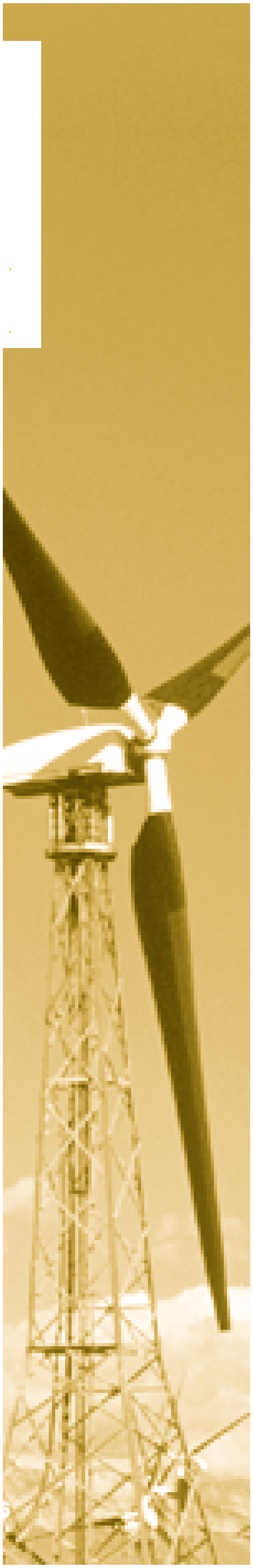


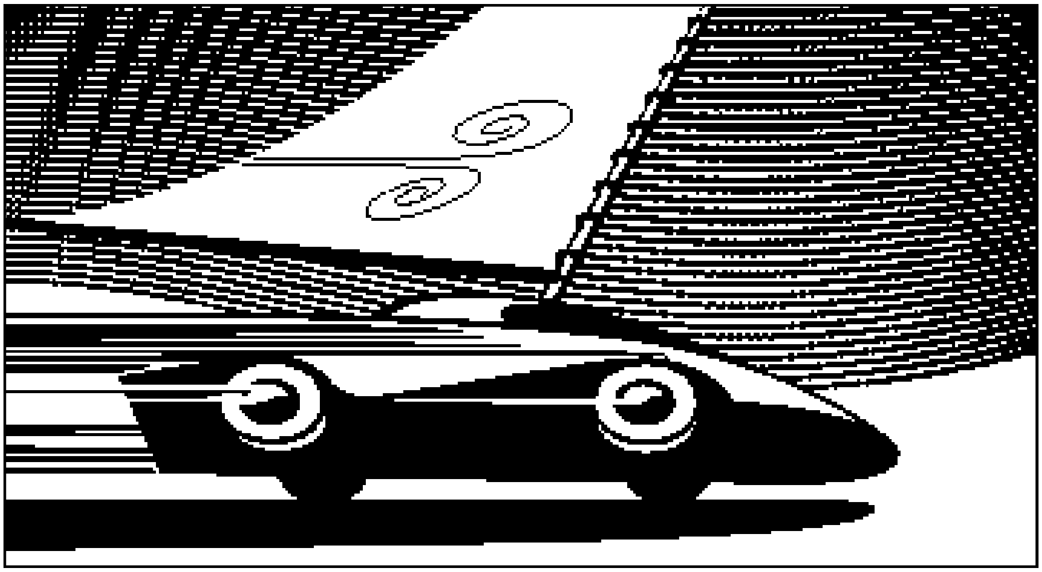
Table of Contents
Classroom Activities – Grades 2-8

Activities for Elementary Grades

Activities for Middle School Grades



Build an Air-powered Car!



Grade level: 2-6

In this activity, young students build a car and learn that moving air pushing against an object can make the object move.

Materials:

Icebreaker

- 8 1/2" x 11" sheet of paper

Activity / per pair

- 3 nonbendable, plastic drinking straws
- 4 Lifesavers™
- 8 1/2" x 11" sheet of paper
- 2 paper clips
- tape
- scissors
- envelope (to hold the straws, Lifesavers, and paper clips)

ZOOMon

- extra materials from the list above

ZOOM links at *pbskids.org/zoom/sci*

Keep experimenting with air power:

- Balloon Car
- Windmills
- ZOOM vehicle
- Junk boats
- Hot air balloon

Kid Feedback:

Hear what kids have to say about the Puff Mobile at *www.pbskids.org/zoom/sci/puffmobile.html.*

Activities:

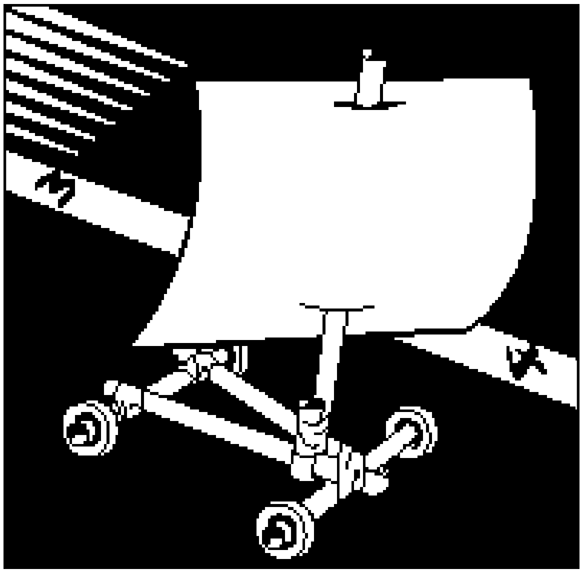
1. Icebreaker

Place a sheet of paper flat on the table. Blow on it. Ask kids to brainstorm how they can change the sheet of paper so it will move farther.

2. Try it Out

Organize kids into pairs and distribute activity materials. Challenge them to build a car that goes 6 feet with the least number of puffs. If kids are having trouble getting started, ask: Which pieces look like wheels? How could you make a sail? What can you use to make a car body? The candy wheels will need to be held in place so they don't roll off the straw. One way to do this is to add tape to the straw on either side of a wheel.

Set up a test track by putting a 6-foot strip of masking tape on a smooth surface, such as an uncarpeted floor or a tabletop. Mark a starting line, at 1-foot intervals, and a finish line. Have the kids test how many puffs it takes to reach the



finish line. Ask: Which parts help the car move? Which parts seem to slow it down? What would you change to make the car move farther with fewer puffs?

3. *ZOOMon*

If there's time, challenge kids to redesign their cars so it takes fewer puffs to reach the finish line. Or encourage kids to keep experimenting at home by changing one variable at a time and making a prediction. Ask: What happens if you use fewer materials? Add a new material like thread spools? Change the size or shape of any part of the car?

4. Connect to Engineering

In real life, engineers design different types of vehicles using different types of power, or fuel. For example, a car is powered by gas, a bike is powered by a person, a carriage is powered by a horse, a sailboat is powered by wind. Engineers are also designing vehicles that run on fuels other than gasoline: wind-powered recreational vehicles, solar-powered cars and hybrid cars (cars that use both electricity and gasoline).

The Puff Mobile is one of eight activities found in the toolkit for *ZOOM Into Engineering.* National Engineers Week is joining forces with the popular PBS children's show *ZOOM.* The show helps young children learn critical concepts for success in science. Through *ZOOM Into Engineering,* EWeek volunteers help students connect what they learn to engineering. Read more about this program at our *ZOOMzone, www.eweek.org.*

Human Suspension Bridge

Grade Level

Grades 4 through 6

Materials

Two pieces of sturdy, wide rope, each 10-12 feet long

Photographs of various suspension bridges, if available

Discussion

Engineers keep our world in motion, particularly on roads and highways.

Engineers may be most noted for designing and building bridges. One of the sturdiest, longest and most elegant of these structures is the suspension bridge.

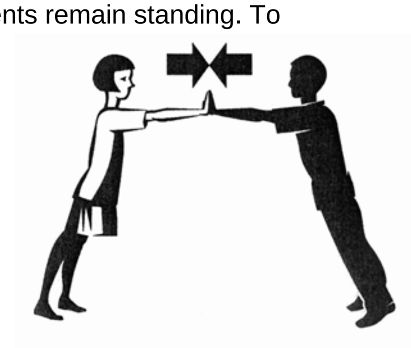
A suspension bridge must be balanced to stand up. It uses tension in the cables to create an overall force of compression in the towers.

Exploration

Before the students become "engineers" in this activity, they need a short course in engineering principles and forces that help support bridges.

First demonstrate the forces of tension and compression. Ask students to stand, each having one partner. To demonstrate tension, have each team member grasp the other's forearms. Both students lean back. Their arms should stretch out between them. Go around to several pairs and lean gently on top of their arms to test their "structure". Explain that when you lean on them you are pushing down and causing their arms to stretch, or be put into tension.

Have the students remain standing. To demonstrate compression, have partners press the palms of their hands together and lean toward one another. The students will be making an arch with their bodies. Go around



to each pair and push on top of the arches. Explain that when you are pushing down you are causing them to push together, or to be put into compression.

If time permits, ask students to look for elements under tension and compression in their classroom.

Activity

1. To build the human suspension bridge, select 16 students to participate.
2. Two pairs of taller students stand across from each other and hold the "cable" ropes on their shoulders. These students are the towers.
3. Four students act as anchors. Each one sits on the floor directly behind each tower and holds the ends of the cables.
4. Eight students can act as suspenders. Put four in a straight line between each opposing tower. They can kneel or sit while pulling the cables down toward the floor.
5. The floor serves as the roadway. The rest of the students in the classroom can act as cars.

Discussion

Ask the students who are acting as towers to describe what forces are at work in their "bridge". Have them describe how each force works upon them. They should feel the rope pulling down on their shoulders. What happens to the bridge if there are no anchors? If there are no suspenders?

You can also discuss the pros and cons of a suspension bridge.

For instance, these bridges are typically found in large cities with lots of boat traffic. They can be built high above sea, or land, with a large span between their towers, leaving the waterway clear for boats. However, they are very costly in materials and time.

This activity was provided for National Engineers Week by the National Building Museum (NBM) in Washington, D.C. For National Engineers Week 1998, the National Engineers Week Committee will launch an exhibition at NBM called "Breaking Through: The Creative Engineer " The exhibit will examine engineering as a creative process in areas from space exploration and high definition television to bridges and microrobotics For more information, check out the National Engineers Week internet site at http:\\www.eweek.org.

Make a Vegetable Oil Tanker

You can make a tanker and clean up a vegetable oil "spill."

Grade Level

Elementary

Materials

- Small piece of aluminum foil
- Cooking oil
- Baking dish half full with water
- Cotton balls or ripped piece of paper towel

Discussion

You've probably heard about oil spilling into a river or the ocean. While accidents are rare, engineers and scientists have had to develop technology to help clean up these spills.

There are several methods used while the oil is still in water.

- Boats with special "skimmers" can remove oil, much like using a ladle in a soup pot.
- Chemicals called dispersants, which are like detergents, help break oil into droplets and then bacteria and other natural organisms in the water can digest the oil.
- Burning is a quick way to be sure a spill doesn't get to shore.
- If the spill does get to the shoreline, sorbents are used to soak it up. Sorbents are made of polyethylene, a plastic (which is made of oil).

Activity

1. Shape a small piece of aluminum foil into a canoe -maybe a little bigger than your thumb.
2. Fill it with cooking oil and float it on a baking dish half full of water.
3. When you're ready, tip it over.
4. Now use some cotton balls or a ripped piece of paper towel to soak it up.

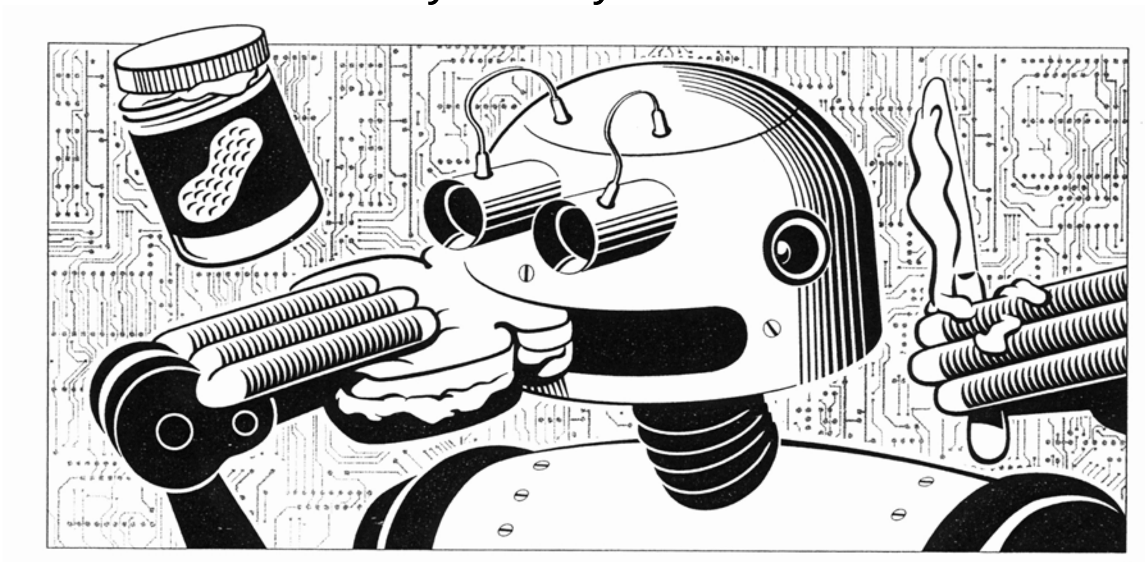
The oil is absorbed by the fibers in the cotton or paper. The only problem is that you would need a whole ship just to carry this "absorbent" around, because there's just not enough room to keep it on the oil tankers themselves.

Engineers and scientists have used absorbent pillows, like cotton balls, to soak up spilled oil. They've also used big floating booms, giant styrofoam logs wrapped in plastic, to contain the oil spill. Try to contain your own oil spill with a loop of string.

Questions for Students

- Can you name some products that are made with oil?
- What other ways can you clean up your spill? (Detergent, a spoon for skimming, etc.)
- While you contain the oil with your string, what happens if a wave comes? (Suggest the students create some movement with a spoon.)
- Which do you think would be hardest to clean and why... a spill in a lake, river or the ocean?

The Microprocessor:
Peanut Butter & Jelly Activity



Goal

Students will understand that the microprocessor follows a precise set of instructions.

Activity

Students will create a precise set of instructions to make a peanut butter and jelly sandwich.

Grade Level

Grades 4-8

For higher grade levels, use a more complicated task such as putting on a coat, tying your shoe.

Key Concepts

The microprocessor is the Central Processing Unit for the computer. It controls what the computer does.

Microprocessors follow a precise set of instructions called a program

Microprocessors do very complex tasks by breaking them down into simple steps.

Microprocessors are often called the brain of the computer, but they are very different from a human brain.

Many people refer to the microprocessor as the "brain" of the computer. You may sometimes hear it called a Central Processing Unit or CPU. Like your brain, it is the central place where information is processed and it tells the other parts of the computer what to do by taking input and directing output. It is very different from a human brain because it does not think for itself; it only does what it is told to do.

Every job a microprocessor does is broken down into a set of separate little operations with a coded instruction for each task. This list of instructions is called a program. You can program microprocessors to perform certain tasks for different situations. Unlike our brains, microprocessors do not think. Therefore the instructions, or program, given to a microprocessor must be very precise.

Lesson

Materials

A sample microprocessor or picture of one to show the class
Chalk and chalkboard or white board with pens or flip chart and pens
Peanut butter, jelly and several slices of bread, dull or plastic knife and a spoon

Directions

Note: This is intended to be a fun activity with lots of student interaction. Do not feel shy about "hamming" up the directions.

1. Tell the class that they are going to write instructions to program a microprocessor that controls a robot. The program will be a set of instructions for making a peanut butter and jelly sandwich. On the front table there are pieces of bread, an open jar of peanut butter and an open jar jelly. There is also a knife and a spoon.

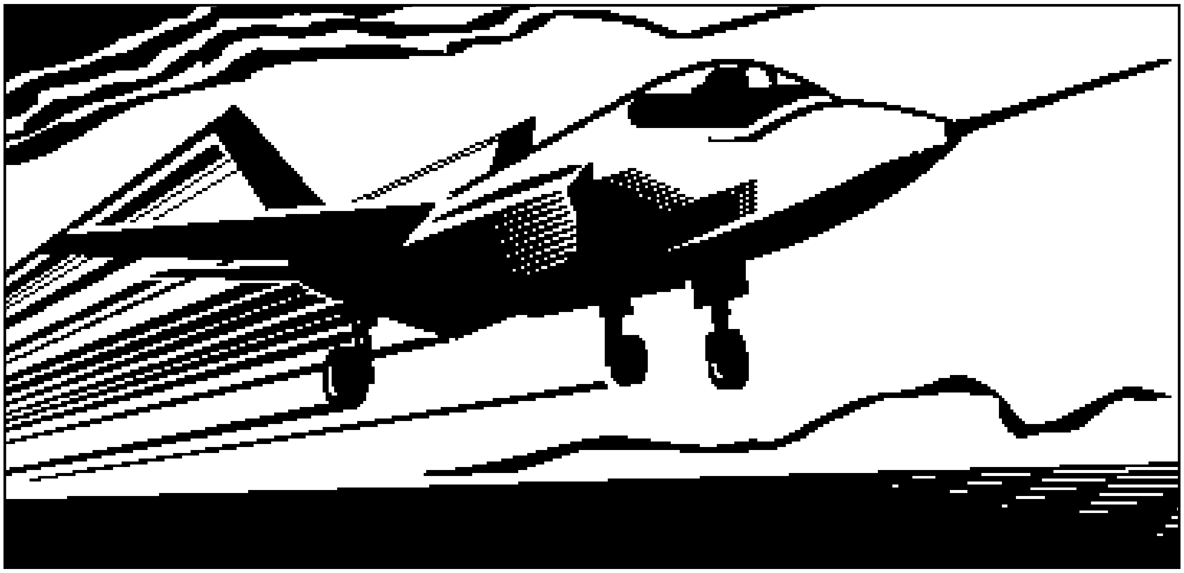
2. You will be the robot.

3. Ask the students to think about how to make a PBJ sandwich and how they would write the program. Students then write the program. 40 minute version-Students work in small groups to prepare their program. Each group submits one set of instructions. 25 minute version-Ask the students for the first instruction, second and so on. Write the instructions on the board. After the first four or five instructions tell the class you will now try the first few.

4. Follow the instructions exactly. The instructions will be unclear and steps will be missing (like using a knife or the bread). If the instruction says '"put the peanut butter on the bread" you might put the jar of peanut butter on the bread. Ask the students what is wrong? They will quickly see that the instructions were not specific enough or possibly whole steps were omitted.

5. Once the class understands that more precise instructions are needed, have the students "de-bug" the program again and then summarize the lesson by reviewing the following: Microprocessors can perform complex tasks when given a precise set of instructions that break that task down into simple steps. The microprocessors can be programmed to handle different situations but, unlike a human brain, the microprocessor cannot make decisions. Therefore the instructions or program must be very exact.

This activity is adapted from Intel Corporation's *The Journey Inside: the Computer Education Kit*.



Grade level: All Ages

In this activity, students conduct an extended experiment in which they change and test different flight conditions. By working in pairs or small groups, they will better understand how research teams of engineers and scientists must work together cooperatively to complete large projects.

Materials:

- 8 ½" x 11" paper, some cut into 2" x 11" strips
- masking tape
- scissors
- measuring tape

Objectives of this activity:

- Understand what forces act on an airplane
- Learn how an airfoil affects air pressure
- See how design differences influence airplane performance

Introduction:

December 17, 2003, marks the 100th anniversary of the first powered, piloted flight, when Orville Wright flew 120 feet in 12 seconds at Kitty Hawk, North Carolina. Ask older students to figure out how many miles per hour that would be.

120 feet/12 seconds = X feet/60 seconds = 600 ft. per minute

600 ft. per minute times 60 minutes = 36,000 ft. per hour divided by 5280 = 6.8 mph

Background:

How is it possible that heavy airplanes (some weighing almost half a million pounds) are able to be supported by air high above the ground?

Because of the shape of the wings, the air under the wings pushes up more than the air on top of the wings pushes down. This difference in air pressure is called LIFT. What's really amazing is why this happens. If we look at an airplane's wing from the side, we can see that it is a special shape called an airfoil. *[See Figure 1]*

As airplanes fly, air is pushed above and below their wings. The air passing over the wing reaches the back of the wing at the same time as the air passing under the wing. The air moving over the wing - which has further to travel around the curved surface - has to go faster than the air moving underneath.

Air that moves slowly (the air going under the wing) creates MORE pressure than air that moves quickly (the air going over the wing). This creates LIFT.

The principle of lift was first proved by a Swiss mathematician named Daniel Bernoulli in the 18th century. Have the students demonstrate Bernoulli's Principle: give them each a strip of paper and have them blow over the top of it. Ask students to **predict** what they think will happen. (The paper will rise.) *[See Figure 2]*

What happened? The students lowered the pressure that was pushing down on the top of the

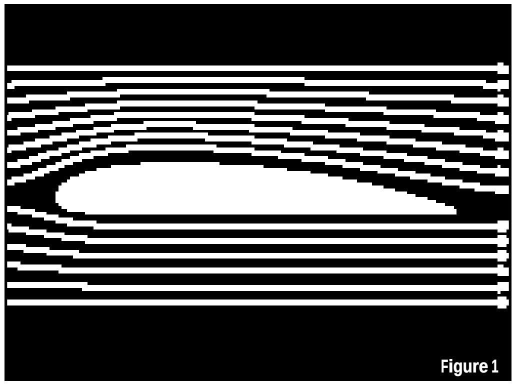


Figure 1

Figure 2

paper, causing the pressure on the bottom side of the paper to push the paper strip up. The same thing happens when air pushes on the bottom side of an airplane's wing.

What forces act on an airplane?

There are four forces acting on an airplane in flight: lift, weight, thrust and drag. *[See Figure 3]*

Lift comes from the wings. What about the other forces?

Weight is a force caused by gravity, directly opposite to the lift force that is pulling the airplane up. For level flight, lift and weight must balance each other out.

Thrust, caused by the airplane's engines, is the force that moves the airplane forward. If an airplane did not keep moving, air would stop moving over and under the wings. Without this movement of air, the wings could not create lift, and the airplane would start to fall back to the ground.

Drag is the force that tries to slow down a moving object. To lessen the drag on an airplane, most airplanes are made more aerodynamic, or streamlined. Just like lift and weight are opposite forces, thrust and drag are opposites to each other too. For an airplane to keep flying, its thrust must be bigger than its drag.

Activity:

Getting Started:

Airplanes are equipped with special control surfaces to give the pilot a way to change the direction and altitude of flight. In this activity the AILERONS (flaps on the back edges of the wings) are the focus. Turns are aided by raising one aileron while the other is lowered.

Help students mark off several target areas on the floor. The target areas should be made with two pieces of masking tape, each at least 4 feet long, placed at right angles as shown, and at least 15 feet away from the launch zone. *[See Figure 4]*

Part 1: The Control Flight

Distribute the paper and ask each student to make the airplane shown in the drawing. *[See Figure 5]*

Demonstrate how to fly the airplane into the target by using the same controls for all 10 test flights: stand in the same location, hold the airplane in the same manner, and use the same force/thrust to throw the airplane. Instruct students how to record their test flight results with an X on the appropriate grid of a data-recording sheet to show the location of each landing.

Students work in teams of 2 to 4 people. First the team conducts a test flight of each partner’s airplane. The team then selects the best plane. Next, one team member flies the airplane 10 times into the target spot from 15 feet away, and the other students record each landing. After all teams have completed this first series of test flights, the class is brought together to discuss their findings. Have

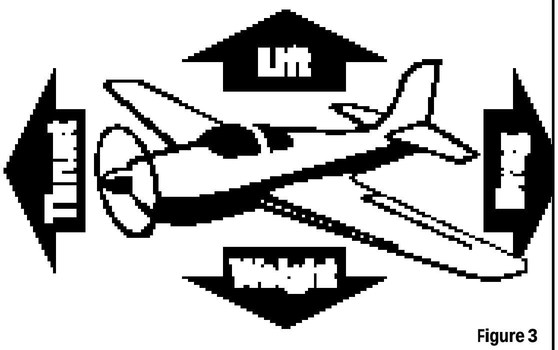


Figure 3

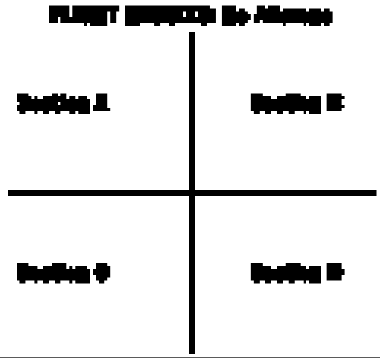


Figure 4

one student at the chalkboard to consolidate all results onto one large grid.

Part 2: Flights with Changes

Show students a sample airplane in which ailerons have been cut as shown. Explain that they are going to experiment by changing the position of ailerons to see how the change affects the direction of the airplanes. Then present this task.

Notice where the ailerons are on the wings of this airplane. Make an aileron on each wing of your airplane by making cuts in about the same locations. On each wing, the two cuts should be about 1 inch long and should be about 1 inch apart.

Ask the students to predict what effect the ailerons will have on the landing patterns. (Remind students that if one aileron is raised, the other must be lowered.)

Teams should use a separate grid to record results for each series of 10 test flights that teams conduct with the ailerons in different positions. Teams should follow the same procedures as in Part 1 when conducting the series of test flights for each airplane.

Closing the Activity:

When all data have been collected, help teams organize and analyze their findings.

Conclusion:

Engineers constantly experiment with test designs and materials to improve existing airplane designs and create new ones. They work to improve safety, to increase performance, and to reduce costs. They ask questions, develop a theory or a model, test their ideas, create designs, and build working models. They change their experiments by varying the conditions.

Further Explorations:

- Ask students what other experiments they would like to conduct to further test their conjectures about flight direction.
- Students may want to design and test different airplanes by varying the width of the wings and the size and placement of the ailerons.
- Students might like to build a wind tunnel on their own to test their different models. Refer them to the American Institute of Aeronautics and Astronautics web site for simple instructions: *http://www.flight 100.org/learn/exp-nqwwt.html*.

This activity was provided by the National Aeronautics and Space Administration, *www.nasa.gov*.

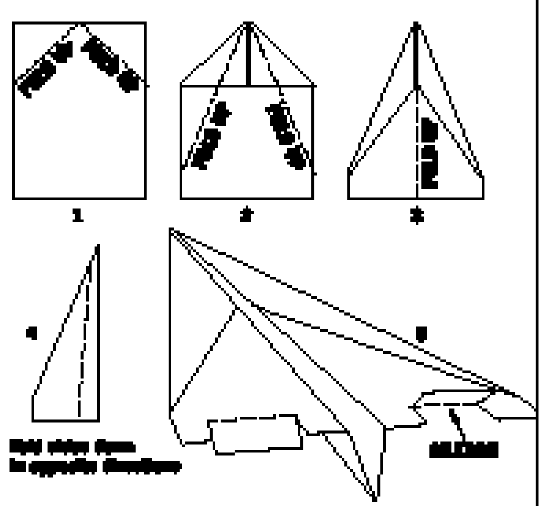
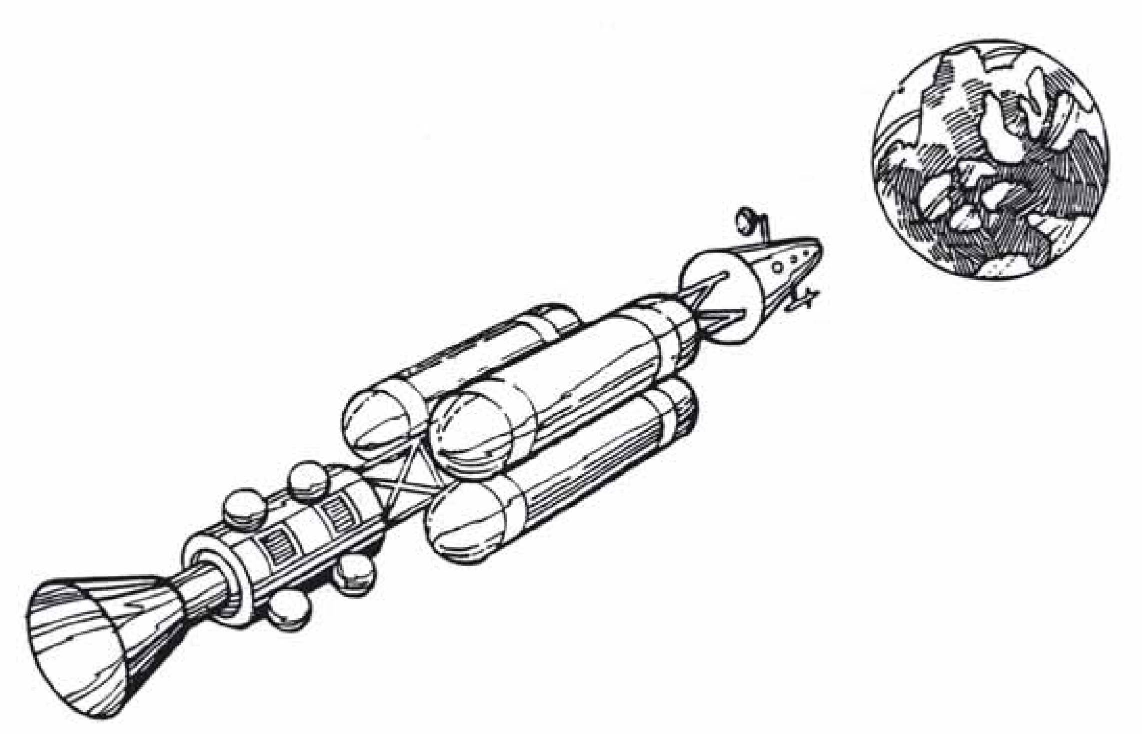


Figure 5

Exploration – Spaceship to Mars



Topic

Designing a spaceship for the trip to Mars.

Description

Students are challenged to work in teams to build and test the structure that will support the modules of an interplanetary spaceship.

Grade Level

Middle School (suggestions are included for extending to lower and upper grades).

Materials Needed

- 6 sheets of copy machine paper
- Masking tape
- Scissors
- Hard cover book or some other weight

Procedure

Step 1 Divide the class into teams of 2 to 4 students each.

Step 2 Distribute one student copy of the activity, to each team. Ask one member from each team to read the description of the manned mission to Mars and the engineering challenge.

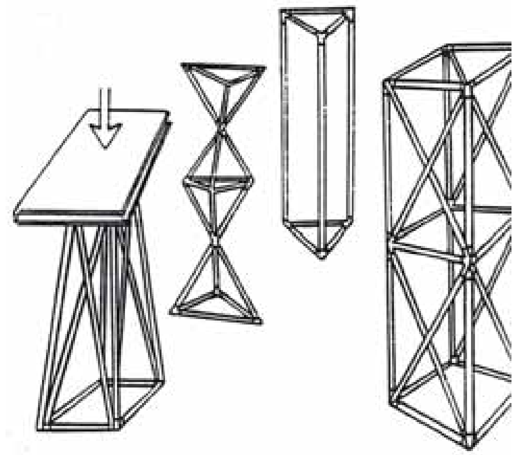
Step 3 Tell each team they have 20 minutes to design and construct their proposal for the spaceship framework. Demonstrate how the framework s will be tested. Refer to the diagram. As the teams are building their models, circulate among them and ask questions about their designs to encourage them to analyze what they are creating. Remind the students to keep track of the materials they use.

Step 4 At the completion of the construction period have each team bring their framework model to the testing area. Invite all the students to speculate on which structure should be the strongest. Discuss why they, made their choices.

Step 5 Begin testing the models by standing the first one up on a flat surface as shown in the diagram and placing the book or other weight on top. Be prepared to catch the weight if the structure collapses. The framework that uses the least amount of construction materials (lowest bid) and supports the weight is the winner.

Discussion

This activity can be adapted to be simple or complex, depending upon the time and equipment available and the level of the students. In its simplest form, the framework that supports the greatest mass of books is the strongest. A more advanced version of the activity would begin the testing determining the mass of the framework for comparison to its strength. The framework with the best mass to strength ratio would win the competition. If a balance for measuring the mass of the framework is not available, a rough approximation of the



mass of individual frameworks can be made by comparing the amount of scraps left over from the construction. Ask the students why it is important that the framework be both strong and light.

In this version of the activity, the students must keep track of the cost of their frameworks. Each sheet of paper represents $10 million in construction materials and labor and every centimeter of tape represents $100,000. By totaling up the materials they used to build their models they can submit a bid on how much the actual framework would cost. As in real life, the company, that submits the lowest bid while fulfilling all design requirements is awarded the contract.

In conducting the strength tests, be sure to relate the weight of the book or other object chosen to the G (gravity) forces the real framework would experience during acceleration. Each component of the spaceship, including the framework itself, has inertia. Inertia is the resistance of a body to a change in motion. If the framework is weak, the inertia of the crew compartment and propellant tanks will cause it to crumble.

During the tests encourage the students to analyze the structures they built. What make some frameworks stronger than another? Examine the geometry of the frameworks. Which geometrical shapes arc stronger? (Triangles, squares, etc.)

For Less Advanced Groups

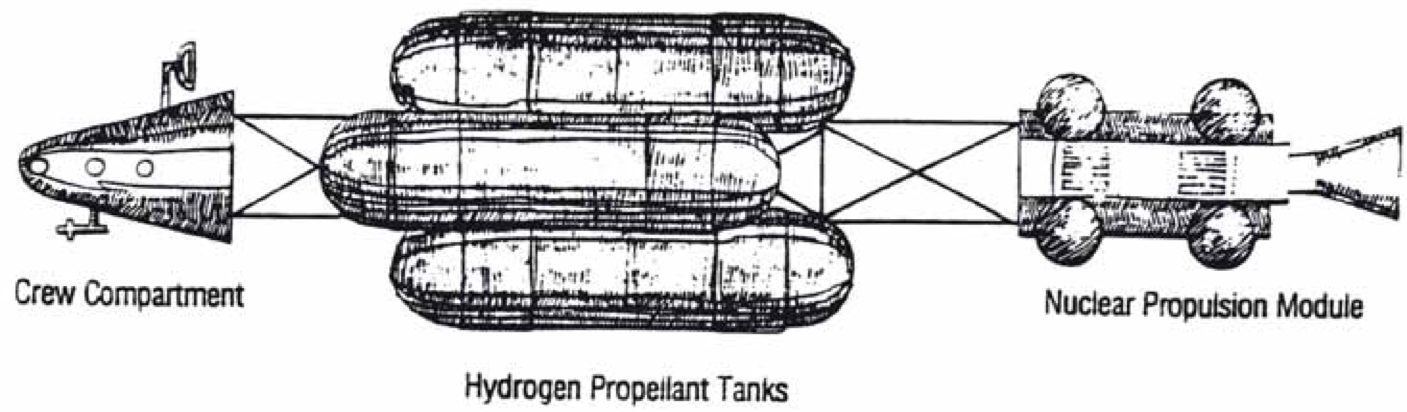
Spend more time preparing students to work in teams.

Think aloud with them about possible configurations and encourage them to think through a design before they begin cutting;

Instead of using paper and tape, have students use plastic straws (not flexible) and large gumdrops to build models. Use less weight for testing

To help students understand how far away Mars is, have them participate in a scale model. Show a cantaloupe for Earth, a lime for the moon, and a peach for Mars to show the relative size of the planets. (For the correct size ratio, use Moon = 1, Mars = 2, Earth = 4.) To demonstrate the distance among them, explain that the moon is 9 ½ times the circumference of the earth in distance. Measure that distance around the cantaloupe and have students hold the string stretched out for the class to see. Then explain that Mars is about 200 times farther from earth than that. In relation to their classroom, where might the end of the string be? On the playground? Across the street?

The National Engineers Week Committee wishes to thank NASA, particularly Gregory L. Vogt, Crew Educational Affairs Liaison, NASA Johnson Space Center, for its help with this project



Student Activity Sheet

Spaceship to Mars

Of all the adventures the National Aeronautics and Space Administration is considering, the one that offers the greatest challenges is the first manned space voyage to the planet Mars. Using current chemical rocket technology, under the most favorable conditions, a round trip to Mars could take as long as 450 to 500 days. Such a trip would require massive amounts of expendables such as food, oxygen, water, power, and propellants. A complete oxygen, water, and nutrient recycling system would be used on the vehicle to reduce the number of expendables required. Furthermore, maintaining astronaut physical and mental health would be an important consideration. For some Mars missions, the entire round – trip voyage might last more than three years!

To reduce the massive effort to make voyage to Mars possible, NASA is working on future technology that could shorten the one-way travel from 120 to 200 days. The technology centers on nuclear thermal engines. Such an engine, if developed, would consist of a nuclear reactor whose heat would be used to raise the temperature of hydrogen gas to about 3,000K. The superheated gas would be expelled out of engine nozzles at a rate that is far greater than is possible with chemical rockets. Higher engine exhaust velocities mean greater efficiency and the vehicle will be able to travel much faster through space. A faster vehicle means a shorter trip and that means fewer expendables will have to be carried.

The first: manned space vehicle to Mars is likely to consist of four major parts. The first is the nuclear propulsion module. Next are the hydrogen propellant tanks. Third is the crew compartment and the last is a framework for attaching all pieces together. Each of the components will be raised to Earth orbit by heavy-lift cargo rockets where they will be assembled for the trip.

Engineering Challenge

Background:

You are part of an engineering design team that has been assigned the task of designing the framework for assembling the components for the Mars vehicle. Other engineering design teams are also working on the problem. The team that comes up with the best design will receive the contract to develop the actual framework. It is your task to make the framework as strong and as light as possible. At the front end of the framework will be the crew compartment. Hydrogen propellant tanks will be attached to the middle and the propulsion module at the other end.

Assignment

Design the Mars space vehicle framework. Use the space below, to sketch your design. Using only, the provided materials, construct a model of your framework to be used for testing its strength. For the test, the framework will be stood on one end. The crew compartment end will be upward. The framework must be at least 40 centimeters tall and must be wide enough at the top to balance a weight your teacher has selected for the test. As you construct your framework, keep track of the materials you use. Each sheet of paper represents an investment of \$10,000,000 in materials and labor and each centimeter of tape an investment of \$100,000. Total the cost of all the materials. If your framework is able to support the weight, the cost of your materials will be your bid. The successful team with the lowest bid will win the competition.

Materials (per team)

- 6 sheets of scrap copy machine paper
- Masking sheet (1 meter strip)
- Scissors

Bid

Number of sheets of paper x \$10,000,000 =

____

Number of centimeters of tape x \$100,000

= ______________________

Framework Design

Human Arch

Grade Level

Grades 5 and up

Materials

Five students and a little floor space

Time

10 minutes

Discussion

Ask the group to describe what an arch looks like. (They may say a curve or rainbow.) See if they can site examples of arches in your community. If not, try to mention something very recognizable. Ask what they think holds up the arch. Explain that this activity explores how arches work.

During the activity introduce the terms force (a push or pull on an object) and compression (a squeezing force pushing the material together.)

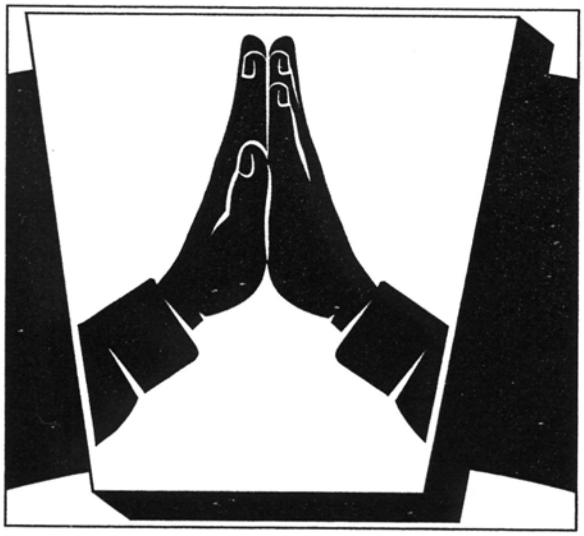
Activity

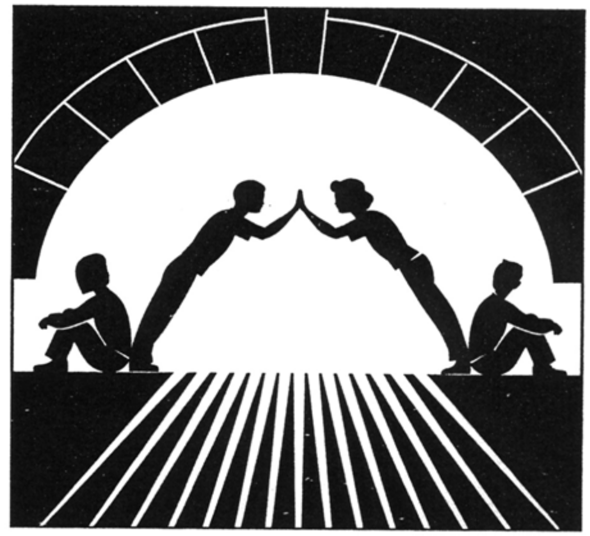
I. Have two students form an arch by placing their palms together and leaning toward each other, sliding their feet back as far as they can.

2. Ask the arch-makers where they feel pushing or pulling (the hands). Ask what would happen if they stopped pushing. (Without compression the arch would collapse.)

3. Have a third student gently pull down on the arch-makers' arms to test the strength of the arch. Ask: How difficult is it to break the arch? Where does the arch need support?

4. Ask two more students to join the arch. Invite the group to brainstorm ways for the two new members to make the arch stronger. Test each suggestion with the same person pulling down each time. Ask: Is it easier or harder to break the arch this time?





Additional Challenges

Ask why it is important to have the same person pull on the arch each time. (This gives a "fair test" by making sure the same pull is used and the same person judges how hard it is to break the arch each time.)

Have students suggest and carry out follow-up investigations such as testing the effect of an arch's width on its strength.

Credits

Excerpted from *Building Big Activity Guide. Building Big* is a PBS television series exploring the world's greatest engineering feats. For other activities visit *pbs.orglbuildingbig.* Funded by The National Science Foundation, National Endowment for the Humanities, The Arthur Vining Davis Foundations, the Corporation for Public Broadcasting, public television viewers, the American Society of Civil Engineers and Siemens.