Engineers in the Classroom

The engineers of the future are sitting in America's classrooms *right* now. Even as early as middle school, students with the aptitude and interest that might lead to an engineering career can be *identified* and *encouraged* toward that pursuit. Sometimes all a child needs is an introduction to something new—a field of study, a career they didn't know existed—to generate interest. Together, education and inspiration can make all the difference in a child's life.

To that end, a major focus of Lockheed Martin Corporation's community outreach effort is *education*. In fact, 50 percent of Lockheed Martin's community contributions and activities are geared toward education—specifically, to engaging students about the field of engineering and the importance of math, science and technology if they want to be an engineer.

Your school visit and classroom presentation is a critical component of that effort. This Presenter's Guide—developed specifically for Lockheed Martin's ***Engineers in the Classroom*** education initiative—is designed to help you make the most of your time and presentation. Through grade-based activities and one-on-one interaction, you will have the opportunity to help students not only gain a better understanding of what engineers do but also learn about some of the various engineering disciplines they could study in college. This guide will help you deliver the message that a future in engineering can be for *anyone*—both boys and girls—with many different interests and many different ethnic and cultural backgrounds.

The easy-to-use demonstrations and activities in this Presenter's Guide will help you to introduce middle school students to the field of engineering and the specific discipline of ***mechanical engineering***. It will help you to inspire the youth of today. And just maybe, help you guide the next generation on the path toward becoming an engineer.

This **mechanical engineering Presenter's Guide** contains the following:

- Presentation Checklist
- Demonstration: The effect of friction
- Activity 1: The force of lift
- Activity 2: Centripetal force on objects in motion
- Activity 3: Mechanical engineering crossword puzzle
- Activity 4: Word-search puzzle
- Activity 5 (take-home): Testing insulation properties
- Activity 6: Building a windmill
- Parent/Guardian Letter and Reading/Resource List

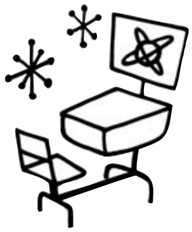
LOCKHEED MARTIN
We never forget who we're working for®

ENGINEERS IN THE CLASSROOM™

Engineers in the Classroom

Introduction

Middle school is a time of dramatic change for young people. They are maturing, yet they are still children in many ways, retaining a youthful fascination with how things are put together. You can build on that interest as you introduce them to the field of engineering and show them what mechanical engineers do.



Most young people have no concept of the many ways their lives are touched by the work that engineers do—from the bicycle and the car in the garage, to the refrigerator that keeps their sodas cool, to the heating and air conditioning systems that keep the house comfortable regardless of the weather.

They also have little understanding of how the math and science that they study each day are linked to the real world—or how mastering these two subjects builds the kind of knowledge that engineers rely on daily to turn ideas into reality and to make life better—and more fun—for all of us.

As part of Lockheed Martin's ***Engineers in the Classroom*** education initiative, you are reaching out to students on a personal level to help them discover how exciting the real-world application of math, science and technology can be. To assist in your student outreach, the ***Engineers in the Classroom*** initiative includes support materials that have been designed for maximum flexibility. You can use the student activity masters in this guide as teaching tools, play the DVDs to show engineering in action, use the poster on the back of the Educator's Guide to launch a discussion, or cover various career resources using the student brochure—or choose a combination of these options. It's up to you!

Target Audience

These materials have been developed to introduce middle school students to the field of engineering and, more specifically, to the discipline of mechanical engineering.

Objectives

- To introduce students to the discipline of mechanical engineering and help them understand what mechanical engineers do
- To show students how STEM (science, technology, engineering, and math) activities apply to the real world
- To encourage students' interest in science, technology, engineering, and math
- To inspire students, especially girls and minorities, to begin thinking about a career as an engineer

Getting Started

If you are making your own arrangements for a school presentation, use the suggestions that follow. If arrangements have already been made on your behalf, skip ahead to **Planning the Visit** on this page.

Making Arrangements with the School: Unless you have already been invited to visit the school, your starting point to arrange a visit should be the principal's office.* Contact the principal, introduce yourself, and explain that you would like to talk with a group of students about engineering as part of Lockheed Martin's ***Engineers in the Classroom*** education initiative. Tell the principal a little about the initiative, especially the learning resources you will bring with you, and ask when it would be convenient for you to schedule a visit. Let the principal know whether you would prefer to meet with one class, several classes one at a time or several classes in a small assembly, and whether you have a particular grade in mind.

Planning the Visit

Remember, educators are busy people. Be prepared to accommodate your presentation to the school's schedule (start time, lunch, dismissal time, etc.). Be sure to obtain contact information for your point person in the school and the classroom teacher (they might not be the same) so you can introduce yourself beforehand by phone or email. And don't forget to send a confirmation email regarding the date, time and venue of your visit. If possible, find out what students have been studying in class. Any guidance the teacher can provide will only make your time with the students more effective.

It's important to find out how much time you will have and how your visit will be structured. For example, will your audience be a class of 25 students, a multi-class assembly, or students attending a career fair? Gear your presentation to be very interactive, with questions and answers and a hands-on activity. **Make sure you review and select in advance the demonstration and/or activity you wish to conduct.** Schools may have a preference regarding the type of student activity you'll be conducting; please check with your point person.

To further prepare for your presentation, gather in advance the components below into an ***Engineers in the Classroom*** Presenter's Assistance Kit (PAK). The items listed below have been developed by Lockheed Martin to assist you in your presentation.

Middle School PAK Components

1. ***Engineers in the Classroom*** carrying case
2. This Presenter's Guide, which provides directions for planning and conducting your school visit, as well as:
   - *Presentation At a Glance* checklist to help make sure you have everything needed for your visit
   - Your choice of six reproducible activity masters to copy and share with students. Note that Activity 6 is adaptable for a wider grade range than just middle school.
   - A two-sided reproducible Parent/Guardian Letter the teacher can send home with students that includes a Reading/Resource List
3. 50 copies of *I Want to Be an Engineer!* middle school student brochure
4. Leave-behind Educator's Guides/Classroom Posters
5. Two short DVDs about engineering
6. Materials for classroom hands-on activities

*If the principal is unresponsive, consider contacting a guidance counselor, a science/math teacher or a PTA member as an entry point.

The Presentation

ATTITUDE: The most important thing you can do is to approach students with an open, friendly and upbeat attitude. Let them know that you are excited about getting to know them and about sharing your enthusiasm for your job with them. Model what you want to promote—curiosity and a keen interest in learning, for example.

EXPECTATIONS: It is not your job to become the classroom disciplinarian, but it is important to establish your expectations up front. For example, do you want questions during the presentation (generally best for this age group) or at the end? Do you want students to raise their hands when they have questions (again, generally the best approach), or to simply blurt them out? The activities in this guide are designed to be fun for students, to engage their imagination, and to show them that engineering can be a pretty amazing career—but there is a fine line between having fun and losing control.

FLEXIBILITY: It's important to be well prepared for your visit and to have a solid understanding of what you want to accomplish during your time with students. However, it's also important to remain flexible and be ready to take advantage of what many teachers refer to as "teachable moments"—the times when a student asks an especially insightful, but unanticipated, question, or when something unexpected happens during the course of a demonstration or activity that provides an opportunity for you to make an important point or connection.

THE OPENING: It's important to capture the students' attention with the first words you speak, so you might want to consider starting with an interesting or amazing fact. For example, "Did you know that if it weren't for engineers, there wouldn't be roller coasters that can do 360-degree loops?" It's important to connect with students and to let them know quickly that what you have to tell them about engineering will be interesting and fun. And be sure to localize your visit by bringing with you hardware and/or technology items from your office that will spark kids' interest in what you do and in engineering in general. Suggest that they check out a cool website, **www.greatachievements.org**, for interesting facts about great engineering achievements of the 20th century.

WHO ARE YOU?: Spend just a minute or two talking about yourself. Remember to speak in terms that students of this age can relate to. Tell the students where you work, what your job title is, and what you do. It is very important to tell the students how you decided on your career and what you studied in college to get where you are today. It's also important to tell students the types of classes they should take and the types of extracurricular activities they should participate in *now* if they want to pursue a similar field of study down the road. Middle school students are just beginning to consider what they want to do as a career; they need some guidance and a sense of realism about what they need to do to get where they want to go in the future.

MECHANICAL ENGINEERING: The primary focus of your presentation should be on helping students understand what mechanical engineers do and how the discipline relates to other engineering disciplines of which they may be aware. Be sure to include examples of the work mechanical engineers do and the special aptitudes, experiences or interests that would help prepare students for this field. Also, discuss and expand upon the **Key Terms** shown on the demonstration and/or activity sheets as appropriate. Above all, look for opportunities to connect the math and science that students are learning today with the skills and knowledge that engineers must have to be successful. Don't overlook opportunities to also provide examples of how language arts studies are important. After all, engineers must be able to write proposals and reports, and present ideas and designs effectively!

GET THEM INVOLVED: Personalize the connection to students' lives as much as possible. Look for ways to make a real-life correlation between the kinds of things you do and the interests of the students themselves.

SHOWMANSHIP: Demonstrations are a good way to help students understand more about engineering. In this guide, we have included instructions for a simple presenter demonstration that you might want to consider. (Be sure you have the necessary materials on hand first.) Hands-on activities are another good way to connect with students. Consider using one or more (if time allows) of the student activities included in this guide. As you work through them with the students, be sure to link what the students are doing in terms of mechanical engineering with examples from your own personal experience.

HANDOUTS: After you finish your presentation, distribute the *I Want to Be an Engineer!* brochure and copies of the Parent/Guardian Letter and Reading/Resource List—or arrange in advance with the teacher to do so. Tell students that they can find information in the brochure about engineering and engineering careers. Ask the teacher if you can invite the guidance counselor to attend your presentation. If you can't, then arrange to meet with him or her afterward to leave a few extra copies of the brochure behind.

Provide a copy of the Educator's Guide/Classroom Poster to the teacher. Encourage him or her to display the poster prominently and to provide time for students to complete the activities on the reverse side. Ask the teacher if he or she would like additional copies of the poster for use elsewhere in the school. Be sure to bring back any unused copies of both the Educator's Guide/Classroom Poster and the *I Want to Be an Engineer!* brochure, along with any activity supplies that can be used again (e.g., washers, straws, etc.).

Lockheed Martin *Engineers in the Classroom*
Acknowledgments

Materials Review
D. Duncan Atchison – Project Engineer/Biomedical Engineer, Lockheed Martin Mission Services
Michael Beck – Director, Research Engineering, Lockheed Martin Headquarters
Dianne Koval Butler – Manager, Corporate Community Relations, Lockheed Martin Headquarters; Project Lead, *Engineers in the Classroom*
Randal Kim Cannon – Aerospace Engineer, Lockheed Martin Aeronautics
Arwen Davé – Mechanical Engineer, Lockheed Martin Mission Services
Ben R. Dusenbery – Mechanical Engineer/Director-Mission Success, Lockheed Martin Space Systems
Jonquele J. Jones – Engineering Planner, Lockheed Martin Aeronautics
Joy Knight – Manager, Community Relations, Lockheed Martin Space Systems
Norman Robbins – Manager, Community Relations, Lockheed Martin Aeronautics
James Sturges – Director, Research Engineering, Lockheed Martin Headquarters
R. Omar Talavera – Design Engineer/Mechanical Engineer, Lockheed Martin Mission Services
Catherine J. Tsairides – Director, Education and Community Outreach, Lockheed Martin Information Systems & Global Services

Curriculum Development
Young Minds Inspired (YMI) **www.ymiteacher.com**

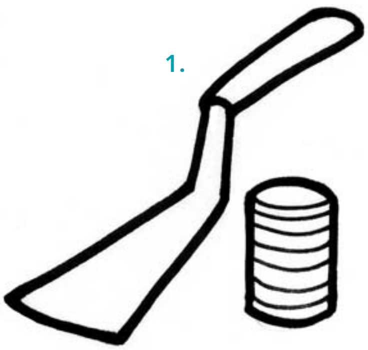
Presenter Demonstration
(may also be used as a student activity)

Time Required: Approximately 10 minutes

The Effect of Friction

Goal: To understand the role of friction in engineering

1.



2.

You will need:

- 12 nickels or quarters
- 1 thin metal spatula
- Smooth tabletop

To lead the demonstration:

1. Stack the coins on the tabletop.
2. For the most impact, do the following with no preliminary explanation: With the spatula blade flat against the tabletop, flick your wrist and slide the spatula under the stack of coins, causing the bottom coin to fly off and the remaining coins in the stack to drop down. (Be sure to practice this prior to your visit so you are proficient during the demonstration.) Repeat the motion several times, causing a few more coins to fly off.
3. Ask if anyone can explain why the stack of coins dropped rather than falling over. Then, explain that what students have just seen is a demonstration of **Isaac Newton's First Law of Motion**. (Remind students that although they may connect Newton primarily with the falling apple and the theory of gravity, he is considered by many to be the greatest figure in the history of science.) In simple terms, Newton's First Law of Motion says that if something isn't moving, it will tend to stay where it is unless it is forced to move. This is known as **inertia**. That's what students saw when the coins were in a stack, and when the remaining coins dropped in a stack as one coin flew away.
4. Next, slide the spatula under the stack of coins slowly enough to make the stack topple over. Ask if anyone can explain what happened. Tell students that Newton also talked about something called **friction**. Friction is what happens when two surfaces move over one another. In this demonstration, friction came from the weight of the stack of coins and the bumpiness of their surfaces. When you moved the spatula swiftly, you pushed hard enough on the bottom coin to overcome the friction between the bumpy surfaces of the last two coins. When you moved the spatula gently, you didn't push as hard and friction took over, causing the bottom two coins to stick together and drag the rest of the stack with them. Ask students to provide other examples of friction.
5. Conclude by explaining that mechanical engineers use their understanding of scientific concepts such as Newton's Law in much of what they do. For example, consider how the brakes on a bicycle are designed to make use of friction.

Key Terms

- **Friction**—the resistance to motion of two moving objects or surfaces that touch
- **Inertia**—the tendency of matter to remain at rest if at rest, unless affected by an outside force
- **Isaac Newton's First Law of Motion**—a principle that says an object not subjected to external forces remains at rest or moves with constant speed in a straight line

ENGINEERS IN THE CLASSROOM™

Using the Student Activity Masters

The following are instructions for using each of the six activity masters included in this guide. Please read each one thoroughly. As you use them, be sure to link the concepts with examples from your own experience. When you are done, collect all reusable materials and return them for other presenters to use.

Activity 1: Up, Up and Away

Goal: To learn about the force of lift

Time Required: Approximately 10 minutes. Pre-cutting the paper will save time.

What You Will Need

- 1 copy of the activity master per student
- 1 sheet of plain white 8½ x 11 paper per student
- Scissors and rulers for each student
- Transparent tape (1 roll per student group)

Objectives

Students will:

- Be able to explain Bernoulli's Principle
- Demonstrate the force of lift by making a wing

Step 1: Distribute the activity sheet. Review the introductory material and describe the kinds of projects mechanical engineers work on. Now tell students that they are going to learn how the force of lift works in relationship to pressure—a principle that helps planes fly.

Step 2: Review the information, keeping explanations clear and simple. (The goal is to help students understand why pressure decreases as speed increases, not to provide an overview of fluid mechanics.)

Step 3: Distribute the paper and have students share the tape. Ask them to:

A. Fold the sheet of paper in half lengthwise. Each half will be 4¼ x 11 inches (10.79 x 27.94 cm). Cut the paper in half along the fold line. Now fold it in half so it measures 4¼ x 5½ inches (10.79 x 13.97 cm).

B. Tape the top edge of the paper so it is approximately ½ inch (1.27 cm) from the bottom edge. Run the tape all the way across the edge. The folded edge of the paper is now curved, like the top of an airplane wing.

C. Slide the wing onto the ruler, hold it in front of you so the fold faces you and the curved part is up, and blow straight at the folded edge.

Step 4: Students will see their wings lift as they blow on the fold. Can anyone explain what happened? The air molecules are compressed when they hit the raised surface of the wing. This causes their velocity to increase, expending more energy and lowering pressure. The pressure under the wing is greater, creating lift.

Step 5: Provide time for students to share their ideas for other ways to demonstrate lift.

Activity 2: And Around We Go

Goal: To analyze the effects of centripetal force on objects in motion

Time Required: Approximately 10 minutes

What You Will Need

Per student group:

- 1 copy of the activity master for each student
- 1 clear 9-inch balloon
- 1 penny

Objectives

Students will:

- Learn how centripetal force relates to students' everyday lives

Step 1: Break students into groups of five each and distribute the activity sheets, balloons and pennies.

Step 2: First lead students through these steps:

A. One student should insert the penny all the way into the body of the balloon so it cannot be sucked out while the balloon is being inflated. Have students blow up their balloons with the penny inside. The balloon is properly inflated when it is almost clear in the middle, but still cloudy at the neck and the end. Tie off the balloon.

B. Tell students to pick up the balloon so the neck end is in their palm. Their thumbs and fingers should extend down the sides of the balloon.

C. Have them hold the balloon palm down and swirl it in a circular motion until the penny begins to spin around inside it, then put their other hand on the bottom of the balloon to stop the balloon from moving.

Step 3: Provide time for each group to consider the questions on the sheet. Ask volunteers to describe what happened. (The penny should have continued to spin after the balloon was stabilized.) Why did students think the penny continued to spin?

Step 4: Explain that it is centripetal force that makes an object like the penny move in a circular path. Centripetal force pulls or pushes objects inward. Centripetal force can be created in different ways—for example, by contact as just shown, or by the gravitational force that keeps planets in their orbits.

Tell students that examples of centripetal force that they might identify with could include clothes spinning in a dryer, satellites moving in orbit, amusement park rides, a gyroscope or spinning top, an airplane doing loops, and a DVD spinning on its turntable. Engineers need to consider centripetal force when they design many things.

Activity 3: All in a Day's Work

Goal: To become familiar with the kinds of things mechanical engineers work on

Time Required: Approximately half of one 45-minute class period, depending on student skill and ability

What You Will Need

- 1 copy of the activity master per student

Objectives

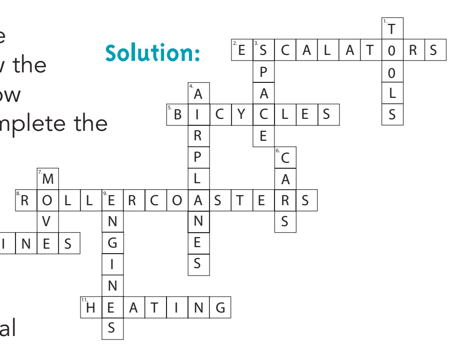
Students will:

- Work independently or as a class to complete the puzzle
- Discover some of the many products with which mechanical engineers are involved

Step 1: Distribute the activity sheet, review the instructions, and allow students time to complete the puzzle.

Step 2: As you review the answers, look for ways to share information about the things mechanical engineers do.

Solution:



Activity 4: From the Machine Shop to Mechatronics

Goal: To introduce terms associated with mechanical engineering

Time Required: Approximately 20 minutes. Although designed to be instructor-led, this could also be used as a self-directed take-home activity.

What You Will Need

- 1 copy of the activity master per student

Objectives

Students will:

- Learn about mechanical engineering terms and considerations

Steps: Distribute one activity sheet to each student. Talk about career opportunities for mechanical engineers in general and, if applicable, specifically at Lockheed Martin. Share some of your own experiences on the job and the interesting things you have done.

Answer Key:

C	R	E	L	G	R	M	A	C	H	I	N	I	S	T	S	T	S	E
T	O	M	R	H	F	R	I	R	I	C	A	H	I	S	T	O	R	Y
D	E	M	S	T	R	A	C	T	E	D	R	A	I	D	R	I	N	D
P	R	O	P	M	A	S	B	A	B	I	L	H	I	S	E	O	R	Y
P	R	O	A	U	E	H	O	R	L	D	E	S	T	R	S	D	D	N
P	U	R	C	E	T	C	R	E	I	E	A	R	C	H	S	P	I	S
R	O	B	E	S	I	E	H	S	S	C	B	U	O	A	A	C	U	T
O	P	R	S	E	M	S	R	A	U	I	A	T	N	R	N	E	N	E
T	R	O	T	I	O	N	B	A	T	G	R	T	S	L	A	B	S	N
O	O	A	R	T	C	T	R	U	I	R	L	V	E	S	L	P	Y	G
T	D	U	U	L	O	U	O	A	D	D	O	N	R	L	Y	O	U	I
Y	U	C	C	O	N	S	T	R	I	G	E	N	U	C	S	Y	P	N
P	C	T	T	O	O	L	S	T	N	A	N	D	I	O	I	T	S	E
E	T	I	U	R	L	E	A	R	L	E	G	T	D	C	S	A	R	E
U	I	N	R	O	O	A	R	O	V	I	L	R	I	E	S	P	R	R
S	O	G	E	V	E	R	N	D	E	N	I	U	O	E	S	U	A	S
T	N	N	S	E	N	O	T	A	M	A	S	I	N	G	S	I	C	L
A	S	T	R	O	N	A	U	T	S	L	H	E	E	E	R	E	G	Y
S	C	I	E	N	T	I	S	T	S	E	N	T	O	S	I	N	R	N

Activity 5: Let's Chill Out

Goal: To understand the role of experimentation in solving engineering problems

Time Required: This activity is self-directed and **designed to be completed at home.** It should take about 45 minutes.

What You Will Need

- 1 copy of the activity master per student

Objectives

Students will:

- Learn that all engineers are problem-solvers
- Make and test predictions

Steps: Distribute one activity sheet to each student to complete at home. Emphasize that there is no "right" or "wrong" solution to the challenge of finding the best way to insulate an ice cube. Students are to think about and predict which materials will work best, and then test their predictions. Encourage students to involve family members in this activity.

Activity 6: What a Windmill!

Goal: To consider the design and function of windmills and wind turbines

Time Required: From 10 to 45 minutes, depending on the amount of experimentation students do

What You Will Need

Note: See the high school Presenter's Guide for an extension to this activity for older students, using the instructions for **Part 2**.

- 1 copy of the activity master per student
- 2 sheets of 8½ x 11 construction paper per student
- 1 wooden pencil with eraser per student
- 1 large-headed straight pin per student
- 1 small bead or button (¼-inch) per student
- Scissors, rulers and pencils for each student
- Craft glue (1 small bottle per student group)

Objectives

Students will:

- Learn that the wind is a renewable source of energy that has been harnessed and used for centuries
- Create their own simple pinwheel windmill **(basic)**
- Work in teams to design an even better windmill **(intermediate)**
- Construct a model of their own design **(advanced)**

Basic instructions for creating a windmill:

Step 1: Distribute the activity sheets and review them.

Step 2: Distribute all supplies.

Step 3: Allow time for students to:

A. Cut the paper into a 7-inch (17.78-cm) square by marking a dot at that distance from one side of their paper. Repeat this three times. Line the ruler up along the dots and draw a line. Cut the paper along the line. Now, repeat the process to create a square. Repeat with the other piece of paper.

B. Draw two diagonal lines that go from corner to corner on each square. Mark a point 3½ inches (8.89 cm) from the corner on each line.

C. Carefully cut along each line, stopping at the mark. These are the blades for the pinwheel windmill.

D. Put the two sheets together and carefully bend the right-hand blade tips at each corner to the center and hold them there as you bend in the other corners.

E. Push the pin through the blade tips and down through the center of the paper. Put a drop of glue on the hole in the bead or button and slide it onto the pin to help hold the pinwheel together. The bead or button will also create a space between the eraser and the paper for Step F.

F. Push the pin into the pencil eraser to make a handle for the pinwheel windmill.

Step 4: Allow time for students to experiment with their miniature windmills. Discuss with the class the following concepts: The pinwheel windmill itself functions only as an energy "catcher." In a real windmill, this energy is "translated" by means of gears or belts attached to an axle (the windshaft) that turns with the blades of the windmill.

Step 5 (Instructions for Part 1—Intermediate): Have students suggest alternative materials and designs that they think might make a better windmill (a plastic straw for a handle and tinfoil blades, or a longer handle and smaller blades, for example). Would those materials be stronger? Easier to work with? Less expensive? Explain that this is the process engineers use when they evaluate design and function.

Step 6 (Instructions for Part 2—Advanced): Divide students into small groups. Bring pictures or have students go online to view pictures of windmills (see **http://servercc.oakton.edu/~wittman/mills/pictures.htm**), then work together to design a better model. Set aside time for sharing and discussion.

Activity 1
Reproducible Master

MECHANICAL ENGINEERING
middle school | instructor-led | hands-on | materials needed

Up, Up and Away

Goal: To learn about the force of **lift**

Introduction: Mechanical engineers work on an amazing variety of projects. Much of what they do deals with motion—everything from the wheels on cars and the systems that make cars run, to jet engines, roller coasters and the inner workings of all kinds of machines. And, like engineers in any discipline, mechanical engineers must have a broad understanding of the scientific and mathematical principles that affect how things move.

One of the forces that affects the movement of airplanes is lift, the force that holds both aircraft and birds in the air. In the 18th century, mathematician Daniel Bernoulli made a discovery that formed the foundation for one explanation of lift. He experimented with what happened as water flowed out of a large tank. His theory—known as **Bernoulli's Principle**—basically says that as the velocity (speed) of a fluid increases, its pressure decreases. This same principle applies to the movement of air over and around an airplane wing. (The molecules in air behave in the same way as the molecules in water.) Airplane wings all have thicker, curved surfaces in the front that taper to a point in the back. Air moving around a wing shaped in this way moves faster over the top than the bottom, and according to Bernoulli's Principle, that means the air on top has less pressure than the slower-moving air under the wing. It's this difference in air pressure that creates the lift needed to keep the plane airborne.

In this activity, you will demonstrate Bernoulli's Principle by creating your own airplane wing and experimenting with it.

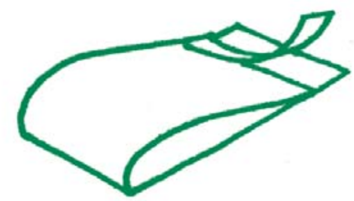
Instructions: Follow the directions given to you to assemble your airplane wing. What happened when you blew on the front edge?

Why do you think it happened?

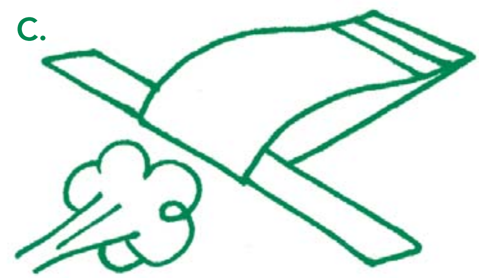
Can you design another experiment that will demonstrate lift? Describe your experiment in the space below.

A.

B.



C.



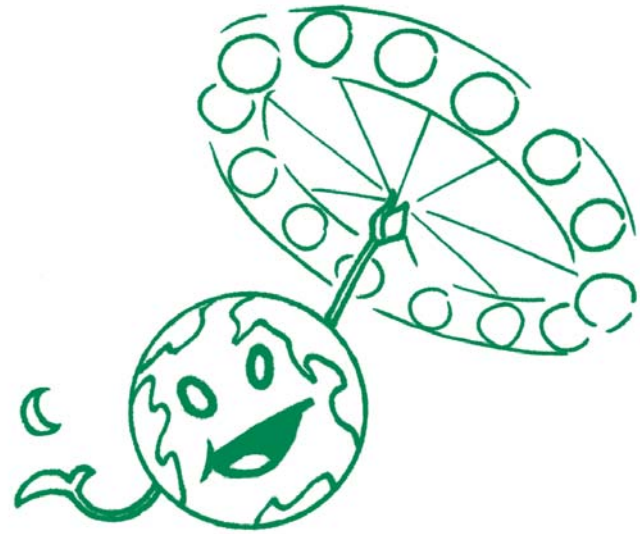
Key Terms

- **Bernoulli's Principle**—a principle that states that an increase in the speed of a fluid produces a decrease in pressure, and vice versa
- **Lift**—the force of air pressure on a wing that causes it to rise

To learn more about Daniel Bernoulli, go to **www-groups.dcs.st-and.ac.uk/~history/Biographies**

ENGINEERS IN THE CLASSROOM™

And Around We Go



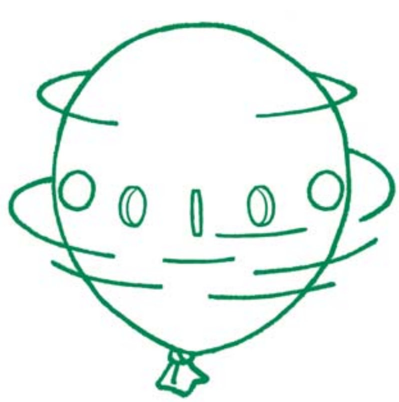
Goal: To analyze the effects of **centripetal force** on objects in motion

Introduction: Mechanical engineers need to know about the different forces that affect objects in motion. Those forces affect things you see and use, too.

In this activity, you will learn about one of those forces.

Instructions: Follow the directions given by your presenter. What did you see during the experiment?

What do you think caused that to happen?



Your group has just demonstrated centripetal force. The word “centripetal” means seeking the center. Have you ever swung a ball on a string? It goes in a circle because the centripetal force of the string pulls on the ball and keeps it on a circular path—just as the side of the balloon kept the penny in its **orbit**. If you were to let go of the string as you were swinging the ball, it would fly off because there would no longer be any centripetal force to hold it in orbit.

With your group, see how many other examples of centripetal force you can list.

Key Terms

- **Centripetal force**—a force that pulls or pushes a moving object toward a center
- **Orbit**—the path taken by an object moving around another object

To learn more about centripetal force, go to
www.sciencenewsforkids.org/articles/20070516/LZActivity.asp

ENGINEERS IN THE CLASSROOM™

All in a Day's Work

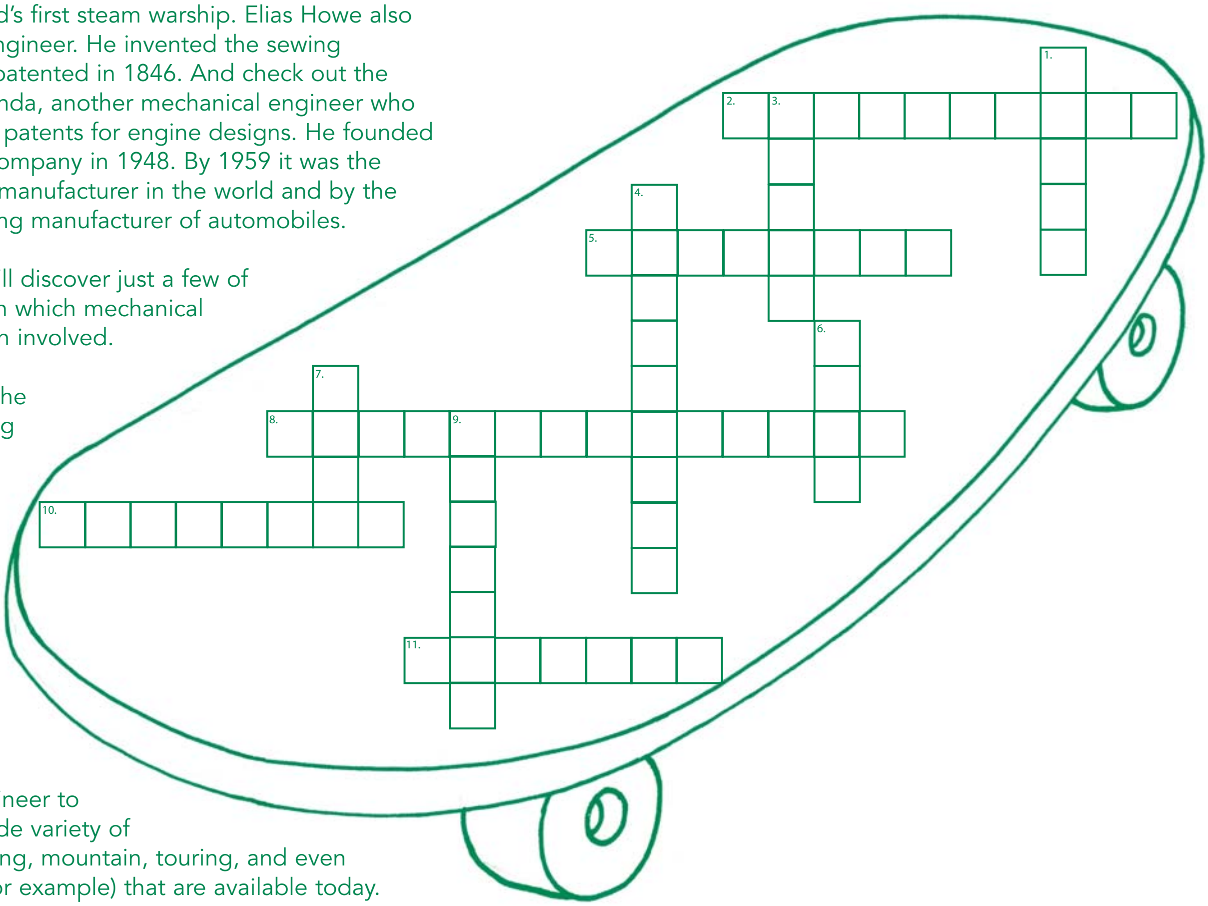
Goal: To become familiar with the kinds of things **mechanical engineers** work on

Introduction: Mechanical engineering is one of the broadest of the engineering disciplines. Mechanical engineers are involved with all kinds of things, from airplanes, bicycles and cars, to skateboards, skis and tennis racquets. That's because all of these things involve various **forces of motion**.

Robert Fulton, who is best known for the steamboat he developed in 1807, was a mechanical engineer. In 1814 he developed the world's first steam warship. Elias Howe also was a mechanical engineer. He invented the sewing machine, which he patented in 1846. And check out the work of Soichiro Honda, another mechanical engineer who held more than 100 patents for engine designs. He founded the Honda Motor Company in 1948. By 1959 it was the leading motorcycle manufacturer in the world and by the 1980s it was a leading manufacturer of automobiles.

In this activity, you'll discover just a few of the other things with which mechanical engineers have been involved.

Instructions: Fill in the puzzle by completing the statements below.



Across

2. Mechanical engineers design elevators and __________ that move people.
5. You have a mechanical engineer to thank for the wide variety of __________ (racing, mountain, touring, and even tandem ones, for example) that are available today.
8. If you've been to a theme park and ridden __________ __________ that did 360-degree loops, you've experienced what a mechanical engineer can do.
10. Elias Howe and Isaac Singer, both mechanical engineers, are known for their work with sewing __________.
11. Is your house cool in the summer and warm in the winter? You have mechanical engineers to thank for your comfort, because they work on air conditioning and __________ systems.

Down

1. Mechanical engineers develop __________ that can be used to build other products.
3. Mechanical engineers work on materials and structures that are used in missions to outer __________.
4. Mechanical engineers work on components used in jet __________.
6. How many makes and models of __________ can you identify? Mechanical engineers were involved in the design and development of every one of them.
7. Mechanical engineers are sometimes called the wheels of the world. That's because they work on so many things that __________.
9. Mechanical engineers design the __________ that power everything from airplanes to lawnmowers.

Key Terms

- **Forces of motion**—effects of the passage of air or water (and forms of water) around or through objects, causing them to respond by means of movement
- **Mechanical engineers**—engineers who deal with the generation and application of mechanical power and the design, production and use of machines and tools

How do car engines and sewing machines work? Find out by searching at **www.howthingswork.com**

Activity 4
Reproducible Master

MECHANICAL ENGINEERING
middle school | instructor-led | worksheet | no materials needed

From the Machine Shop to Mechatronics

Goal: To introduce terms associated with mechanical engineering

Introduction: Mechanical engineers design, build and operate everything from the tiniest microscopic parts to giant gears. They're involved with everything from laser technology to conveyer belts, from fishing rods to power plants, and from golf balls to jet fighters.

In this activity, you will learn a little about some of the things mechanical engineers do and what they might use when they do it.

Instructions: Find the capitalized words from the following paragraph in the puzzle and circle them.

At Lockheed Martin, mechanical engineers do some pretty cool things. They work with ASTRONAUTS, SCIENTISTS and other engineers from around the world. They use COMPUTER-AIDED DESIGN programs to create three-dimensional models. They create, or FABRICATE, PROTOTYPE models. They test those models and do STRESS ANALYSIS calculations. They design SPACE STRUCTURES and TOOLS that are used in space. They work with MACHINISTS in shops and they oversee tests done in LABS. They draw on a wide range of knowledge as they do their jobs—not just math and science and MECHATRONICS, but ENGLISH, HISTORY and even ART, too.

P.S. Anyone know what **mechatronics** is? It's the study of electro-mechanical things like robots, and it was one Lockheed Martin mechanical engineer's favorite course in college!

C	R	E	L	G	R	M	A	C	H	I	N	I	S	T	S	T	S	E
T	O	M	R	H	F	R	I	R	I	C	A	H	I	S	T	O	R	Y
D	E	M	S	T	R	A	C	T	E	D	R	A	I	D	R	I	N	D
P	R	O	P	M	A	S	B	A	B	I	L	H	I	S	E	O	R	Y
P	R	O	A	U	E	H	O	R	L	D	E	S	T	R	S	D	D	N
P	U	R	C	E	T	C	R	E	I	E	A	R	C	H	S	P	I	S
R	O	B	E	S	I	E	H	S	S	C	B	U	O	A	A	C	U	T
O	P	R	S	E	M	S	R	A	U	I	A	T	N	R	N	E	N	E
T	R	O	T	I	O	N	B	A	T	G	R	T	S	L	A	B	S	N
O	O	A	R	T	C	T	R	U	I	R	L	V	E	S	L	P	Y	G
T	D	U	U	L	O	U	O	A	D	D	O	N	R	L	Y	O	U	I
Y	U	C	C	O	N	S	T	R	I	G	E	N	U	C	S	Y	P	N
P	C	T	T	O	O	L	S	T	N	A	N	D	I	O	I	T	S	E
E	T	I	U	R	L	E	A	R	L	E	G	T	D	C	S	A	R	E
U	I	N	R	O	O	A	R	O	V	I	L	R	I	E	S	P	R	R
S	O	G	E	V	E	R	N	D	E	N	I	U	O	E	S	U	A	S
T	N	N	S	E	N	O	T	A	M	A	S	I	N	G	S	I	C	L
A	S	T	R	O	N	A	U	T	S	L	H	E	E	E	R	E	G	Y
S	C	I	E	N	T	I	S	T	S	E	N	T	O	S	I	N	R	N

Key Terms

- **Computer-aided design (CAD)**—the use of computer programs and systems to design detailed two- or three-dimensional models of physical objects, such as mechanical parts, buildings and molecules
- **Mechatronics**—the study of electro-mechanical objects like robots
- **Prototype**—an original of anything that serves as a model for others like it

Computer-aided design is used for everything from designing clothes to creating movie characters. Find out how some cool cars were "brought to life" at **http://management.cadalyst.com/cadman/article/articleDetail.jsp?id=381857**

ENGINEERS IN THE CLASSROOM

Let's Chill Out

Goal: To understand the role of experimentation in solving engineering problems

Time Required: Approximately 45 minutes

Materials Needed:
- 2 ice cubes
- A plate
- A shoebox (this is the foundation for your cooler)
- Wax paper
- Aluminum foil
- Newspaper
- Tape
- A watch or kitchen timer
- A ruler

Introduction: It's not rocket science: If you want to chill those sodas you just bought, you put them in the refrigerator. Problem solved.

But have you ever thought about who solved the bigger problem of how to design that refrigerator in the first place? It was engineers, including mechanical engineers.

Engineers solve problems all the time in their jobs. So, make like an engineer and solve a problem of your own.

In this activity, your challenge is to design a cooler that will prevent an ice cube from completely melting for at least 30 minutes.

Instructions:

1. Get Ready...

You can use any of the materials listed above in any way you wish to make your cooler. The idea is to **insulate** the ice cube from the warm air in the kitchen and keep it from melting as quickly as the one sitting on a plate.

What materials will you use?

____

____

____

How do you think your chilled-out cube will compare to the cube on the plate at the end of 30 minutes?

____

____

Now make your cooler!

2. Get Set...

Once you're ready, take two ice cubes out of the freezer. (Make sure the cubes are the same size.)

Measure the width, length and height of one of the cubes.

My ice cube is

_______ inches (_______ cm) wide

x

_______ inches (_______ cm) long

x

_______ inches (_______ cm) high.

3. Go!

Now, put the chillin' cube in the cooler and the **control** cube on the plate.

Write your start time here: ____________

Keep track of the time. After 30 minutes have passed, measure each of the cubes.

Chillin' cube: _____ inches (________ cm) wide x
_____ inches (________ cm) long x
_____ inches (________ cm) high

Control cube: _____ inches (________ cm) wide x
_____ inches (________ cm) long x
_____ inches (________ cm) high

Did the outcome match your prediction? __________

What changes do you think would make your cooler work better? Make your modifications, get two new ice cubes and try again!

Key Terms

- **Control**—a standard of comparison for checking the findings of an experiment
- **Insulate**—to prevent the passage or leakage of electricity, heat, sound, radioactive particles, etc., by covering with a nonconducting material

For more experiments you can do at home, go to **http://homeschooling.gomilpitas.com/directory/Physics.htm**

What a Windmill!

Goal: To consider the design and function of windmills and **wind turbines**

Introduction: You've probably seen pictures of windmills—especially the ones that are so common in the Netherlands. They are supported by huge towers of stone or wood and have four to six blades that range from 20 to 40 feet (6.10 to 12.19 meters) long. Although windmills are typically associated with the Netherlands, they can be found all over the world. Most modern American windmills are supported by towers made of steel girders, and the metal blades are about 4 feet (1.22 meters) long.

Windmills use the power of the wind for many different purposes—pumping water, driving small sawmills and powering electric generators, for example. Giant windmills, known as wind turbines, are often built in groups that are known as wind farms. They can produce enough wind power to generate a significant amount of electricity. Wind turbines are most common in Europe, where Denmark has set a goal of generating 50 percent of its electricity through the use of wind power by the year 2030. That's a pretty amazing goal. But, then, much of the work that mechanical engineers do is pretty amazing, too.

In this activity, you will consider the use of windmills as a source of renewable energy. Follow your presenter's instructions to either create the pinwheel windmill shown here, or to research and design an advanced windmill or wind turbine.

Basic Instructions for creating a windmill: Follow the directions you are given. If making your own pinwheel windmill, experiment with it by holding it in different positions as you blow on it. See if you can find the best way to make it spin and describe it here:

____

____

____

If you look at pictures of windmills, you can see a small **rotor** at the center of the blades. That's how the windmill spins in the wind—similar to how your pinwheel windmill spins when you blow on it.

Part 1. Instructions: Follow your presenter's directions, then list other materials that you think would make a good pinwheel windmill.

____

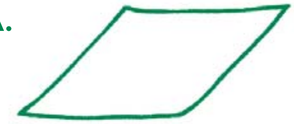
____

Part 2. Instructions: If directed, look at some pictures online and then sketch your idea of a better windmill on the back of this sheet. Work with other members of your team by combining the best features of each person's design into the absolute coolest windmill you can create—one that perhaps has a specific new use or purpose.

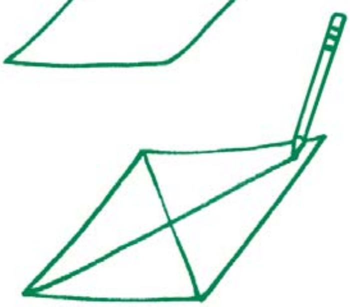
Key Terms

- **Rotor**—a system of rotating wings or airfoils together with their hub, as on a helicopter or windmill
- **Wind turbines**—machines that convert the wind's energy into rotary mechanical energy, which is then used to do work

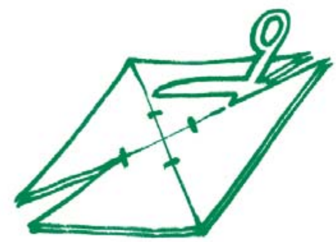
A.



B.



C.



D., E. and F.

To learn how windmills create energy as wind turbines, go to **www1.eere.energy.gov/windandhydro/wind_how.html**

ENGINEERS IN THE CLASSROOM™

Dear Parent or Guardian,

As part of Lockheed Martin Corporation's K-12 education initiative, ***Engineers in the Classroom***, a guest recently visited your son or daughter's school and spoke about the field of engineering.

As you may know, engineering is a very broad field that employs people in every major industry and includes many different disciplines. The guest speaker in your child's class spoke specifically about what *mechanical* engineers do, what types of products they create, and how they make a difference in our everyday lives. Your child learned that engineers like to solve problems and puzzles, are curious about how things work, and are interested in math and science.

At Lockheed Martin, one of the world's leading systems and technology companies, engineers work on exciting technical challenges for projects of global significance. These include developing an advanced crew exploration vehicle, *Orion*, for missions to the Space Station, moon, Mars, and beyond; and high-tech information technology projects such as computer software that ensures Social Security checks arrive on time—to name just a few.

While earnings for engineers vary by discipline, as a group engineers earn some of the highest average starting salaries among college graduates. According to the U.S. Department of Labor, career opportunities in engineering are only expected to increase for the future engineers sitting in classrooms today. In the coming years, many of these job openings will arise from the need to replace engineers who retire or who move into management, sales or other professional opportunities.

Salary range, mechanical engineering: $44,000-$100,000*

You can help your child consider engineering as a career by encouraging them to take as many math and science classes as they can and to take part in extracurricular activities such as the ones listed on this sheet. Studies show that students who do not have a strong foundation in math and science have little chance of success in technical college-degree programs. Students need to make smart choices now if they want the option later to pursue a career in engineering. Now is the time to nurture your son or daughter's interest in math and science—but the window of opportunity is a narrow one.

According to "The Math Path" (**www.learndoearn.org**)—a student credentialing system that helps middle and high school students prepare for the challenges of college—the student who completes only Algebra I has an 8 percent chance of earning a college degree, versus an 80 percent chance for the student who completes calculus.

What you can do at home to encourage an interest in math and science:

- Look for opportunities to point out the practical applications of math and science in everyday life—the knowledge you need to balance a checkbook, modify a recipe, or install a new computer program, for example.
- Challenge your child to solve the Sudoku puzzles that appear in many newspapers and magazines, or to unravel the solutions to mystery stories. These are fun ways to practice logic and analytical skills.
- Talk with your child about engineering innovations such as cell phones or iPod®s. Does your child think he or she could make something better?
- Nurture curiosity. Visit museum exhibits on science and inventions in which your child expresses interest.

Preparing for a career in engineering:

It is important to have your child read and learn all they can about engineering as a career. If you know an engineer, have your child talk with him or her about what the job is like. There are also some excellent television programs that will give your child a look at what engineers do. Be sure that your son or daughter received a copy of the student brochure, *I Want to Be an Engineer!*, that the speaker brought to the class presentation. If they didn't, check with their teacher to get a copy.

Besides a strong background in math and science, extracurricular activities are also important. Encourage participation in the school math or science club—or even the future engineer's club—if they are available. There are also a number of programs and organizations outside of the classroom that will help develop your child's interest in engineering, including:

- Boy Scouts of America offer an engineering Merit Badge. Talk with a troop leader to find out more.
- *FIRST LEGO League* (**www.usfirst.org**)—a robotics challenge for middle school students.
- Girl Scouts of the USA offer activities that can help build skills toward earning the "Building a Better Future" interest patch. Talk with a troop leader to find out more.
- *MATHCOUNTS®* (**www.mathcounts.org**)—a national math enrichment, coaching and competition program.
- *National Engineers Week* (**www.eweek.org**)—a week-long celebration plus competitions for students at all grade levels.
- *Science Olympiad* (**www.soinc.org**)—team-oriented science and technology competitions at the local, state and national levels.
- *Space Day* (**www.spaceday.org**)—held each year on the first Friday in May, this event is dedicated to celebrating the exploration and use of space.
- *Team America Rocketry Challenge* (**www.rocketcontest.org**)—teams of students build and fly model rockets; top scoring teams attend a national competition.

As a parent or guardian, you play an integral part in helping your child make the critical decisions that will affect their future. The academic and extracurricular choices you make together today allow a career as an engineer to be an option tomorrow.

Sincerely,

Jim Knotts

Jim Knotts
Director, Corporate & Community Affairs
Lockheed Martin Corporation

*From *Career Opportunities in Engineering*, by Susan Echaore-McDavid and Richard A. McDavid (Checkmark Books, 2006)

Visit your local library or bookstore to find these books about math, science and engineering.

Books About Math

- *A to Z Women in Science and Math*, by Lisa Yount (Facts on File, Inc., 2007).
  Biographical information about more than 150 women from all eras of history who have worked in the fields of science and math.

- *Algebra to Go: A Mathematics Handbook*, by Great Source Education Group (Scholastic, 2006).
  A good reference for kids and for parents who want to help their children with algebra and pre-algebra.

- *Math Trek: Adventures in the Math Zone,* by Ivars Peterson and Nancy Henderson (Jossey-Bass, 1999).
  Each chapter visits a different section of an amusement park called the MathZone, where readers are challenged to solve math-based problems and puzzles.

Books About Science and Inventors

- *Amazing Leonardo da Vinci Inventions You Can Build Yourself*, by Maxine Anderson (Nomad Press, 2006).
  An introduction to the life, world and mind of Leonardo da Vinci through hands-on projects that explore his inventions.

- *American Women Inventors*, by Carole Ann Camp (Enslow, 2004).
  Profiles of 10 women inventors in areas including medicine and space exploration highlight women's breakthrough roles in male-dominated professions.

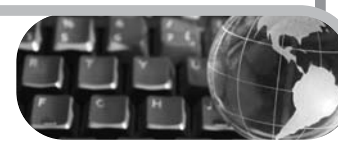
- *Why? Experiments for the Young Scientist*, by Dave Prochnow and Kathy Prochnow (Tab Books, 1992).
  An easy-to-follow book of hands-on science experiments with detailed materials lists, step-by-step directions and clearly drawn illustrations.

Books About Engineering

- *Cool Careers for Girls in Engineering*, by Ceel Pasternak and Linda Thornburg (Impact Publications, 1999).
  Profiling women engineers in 11 different disciplines, including mechanical, software and electrical engineering, this book will show readers that engineering isn't just for men, that it's a field with many opportunities, and that it's "just plain fun."

- *Engineering Projects for Young Scientists*, by Peter H. Goodwin (Franklin Watts, 1990).
  Designed to show young people how fascinating engineering can be, this book helps them apply basic engineering principles as they complete projects in a range of areas, including the design of bridges, cars, rockets, and even amusement park rides.

- *Opportunities in Engineering Careers*, by Nicholas Basta (VGM Career Books, 2002).
  An overview of the main engineering fields, information on the type of education required to become an engineer, and descriptions of various engineering work environments.



Online Resources

- American Society for Engineering Education K-12 Center (**www.engineeringk12.org/students**)
- Discover Engineering.Org (**www.discoverengineering.org**)
- Engineer Girl! (**www.engineergirl.org**)
- How Stuff Works (**www.howstuffworks.com**)
- Junior Engineering Technical Society (**www.jets.org**)
- Lockheed Martin Engineers in the Classroom (**www.engineersintheclassroom.com**)

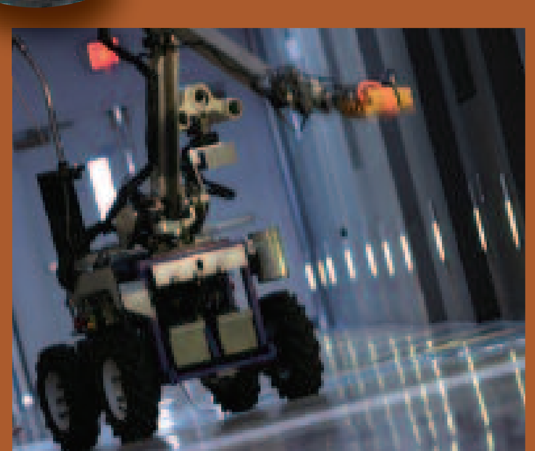
LOCKHEED MARTIN
We never forget who we're working for®

ENGINEERS IN THE CLASSROOM™

My friends call me a gearhead 'cause I gotta know how things work. But I already know what works for me.

The MULE – Lockheed Martin's Multifunction Utility/Logistics and Equipment vehicle – is a robotic workhorse with in-hub motors on each wheel that can power through any terrain. Whether rigged for combat, transport or mine detection, the MULE marks a breakthrough in unmanned vehicle technology, offering America's Future Force ground troops unparalleled support.

I Want to Be a Mechanical Engineer!



My name is **Michael Norman** and I *am* a mechanical engineer. I work for **Lockheed Martin** and helped make the **MULE a marvel of robotic technology.**

LOCKHEED MARTIN
We never forget who we're working for®

ENGINEERS IN THE CLASSROOM™