Engineers in the Classroom

National Standards

The activities in this guide address the following National Education Standards.

National Science Education Standards

- **Science as Inquiry:**
  - Use appropriate tools and techniques to gather, analyze and interpret data.
  - Think critically and logically to make the relationships between evidence and explanations.
- **Abilities of Technological Design:** Design a solution or product.

National Standards for Technological Literacy

- **Design:** Students will develop an understanding of:
  - the attributes of design.
  - engineering design.
  - the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
- **Abilities for a Technological World:** Students will develop the abilities to apply the design process.
- **The Designed World:** Students will develop an understanding of and be able to select and use:
  - energy and power technologies.
  - information and communication technologies.
  - transportation technologies.

National Standards for School Mathematics

- **Data Analysis and Probability:** Formulate questions, design studies and collect data.
- **Problem Solving:** Apply and adapt a variety of appropriate strategies to solve problems.
- **Communication:** Recognize and apply mathematics in contexts outside of mathematics.

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ENGINEERS IN THE CLASSROOM™

Dear Educator,

Thank you for allowing a guest to come into your classroom as part of Lockheed Martin's K-12 education initiative, ***Engineers in the Classroom***. Education is a major focus of Lockheed Martin's community outreach. In fact, 50 percent of our community contributions and activities are geared toward education—specifically, toward engaging students about the field of engineering and the importance of science, technology and math if they want to be an engineer.

As part of Lockheed Martin's commitment to education and in support of the STEM (**science**, **technology**, **engineering**, and **math**) focus in America, we are pleased to provide you with this Educator's Guide, designed to help you build on what your students learned during their visit with an engineer. The guide includes three reproducible activities that will help teach your students firsthand how engineers use science, technology and math to solve problems and make a difference in the world. **Activities 1** and **2** are designed to be completed in the classroom, while **Activity 3** is a take-home project that students can complete on their own or with a family member.

To further strengthen the home/school connection, the presenter has provided each of your students with a brochure and a copy of a take-home letter designed to encourage further exploration in the field of engineering. These materials contain extracurricular activity suggestions, online resources, and a reading list of age-appropriate books on science, engineering and math. There is also valuable information on engineering careers, including some ideas for how to prepare middle school students academically for a career as an engineer. Please be sure that each student in your class has received these materials, and encourage all students to share the materials with their families.

Engineering is a very broad field that includes many disciplines, integrates both engineering and business principles, and employs people in every major industry. 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.

Lockheed Martin is proud to join you in teaching students how exciting the real-world application of science, technology, engineering, and math can be. We trust you will find that the activities in this guide and those presented in your classroom today help light the fire of imagination in your students that will lead them toward a career in engineering!

Sincerely,

Jim Knotts
Director, Corporate & Community Affairs
Lockheed Martin Corporation

Activity 1 Hot Wheels!

Goal: To gain hands-on experience in working, as engineers do, with forces of motion
Time Required: Approximately 30 minutes (may also be used as a self-directed take-home activity with classroom follow-up)

Materials Needed

- 1 copy of the activity master per student

Per student group:

- 1 piece of medium-weight corrugated cardboard approximately 5 x 6 inches (12.7 x 15.24 cm), cut so the holes are visible along the 6-inch edge
- 1 rubber band approximately ¼-inch wide with a 3½-inch perimeter
- 1 wooden skewer (like those used for shish kabob)
- 2 blank CDs or DVDs
- 1 roll of duct tape
- 1 ballpoint pen
- 1 ruler
- Scissors

The invention of the wheel

thousands of years ago has been called the most significant technological breakthrough of all time. Almost every modern convenience we have today makes use of the wheel in one way or another. For most people, however, the first thing that comes to mind when they think of the wheel is the car or automobile. The world's first true automobile was designed and built in the late 1700s by a French military engineer named Nicholas-Joseph Cugnot. It had three wheels and was powered by steam. We've come a long way from Cugnot's huge, heavy contraption. Today's engineers are always looking for something better—from sleeker, more aerodynamic styling, to alternative, renewable sources of power that can reduce the amount of carbon emissions and our dependence on oil.

Objectives

Students will:

- Practice the engineering strategies of building, testing and redesigning as they construct a simple car
- Learn how potential and kinetic energy affect movable objects

Step 1:

Provide some background about wheels and cars (see box above), and then tell students that they are about to build a car that runs on a thoroughly renewable source of power—the kinetic energy provided by a wound-up rubber band.

Step 2:

Distribute one activity sheet to each student. If students will be completing the activity in class, divide them into design teams. Distribute the supplies and lead students through the steps on the activity sheet. (If students will be completing the activity at home, first review the steps to be sure they understand what they are to do, as well as the troubleshooting strategies on the next page.)

Step 3:

Provide time for students to demonstrate their cars and share problems, successes and plans for their redesign if needed.

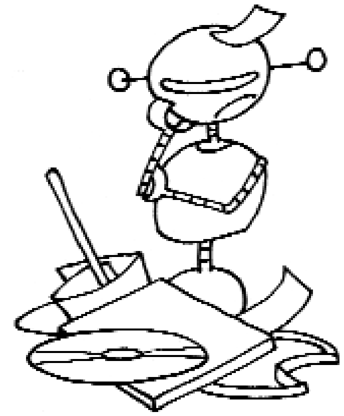
Troubleshooting the Rubber-Band Car

Problem 1—wheels don't spin freely: Make sure the tab on the axle isn't hitting the chassis. If it is, make the notch a little deeper. Make sure the rubber band isn't jamming against the cardboard. If it is, try wrapping it more carefully. Making the notch deeper may also help.

Problem 2—the cardboard chassis buckles: Strengthen the cardboard by gluing or taping an extra strip of cardboard to the underside along the length of the chassis.

Problem 3—the car doesn't move: Check the duct tape to make sure the wheels are attached securely to the axle.

Problem 4—the rubber band slides off the tab: Add another layer or two of duct tape to make the tab more stiff.



Activity 2

Cracking the Code

Goal: To develop a basic understanding of one application of binary coding, the basis of all computer operations

Time Required: Approximately 20 minutes

Materials Needed

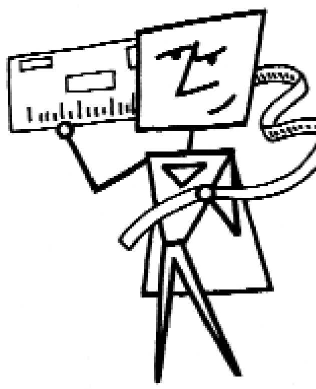
- 1 copy of the activity master per student
- Several envelopes that bear United States Postal System (USPS) bar codes, to use as examples

Objectives

Students will:

- Learn how to decode USPS bar codes
- Become aware that engineers from several disciplines can be involved in a single engineering application

Step 1: Begin by showing students examples of envelopes that have a USPS bar code. Ask if anyone can explain what it is. Explain (or confirm) that it is the code used by post office computerized scanning equipment. The code allows the automated mail-sorting operation to route each piece of mail to its proper destination. This is one application of binary coding. Explain that everything a computer does is based on binary code. Ask if anyone knows why it's called binary code. Explain (or confirm) that binary, which means "two," refers to the fact that only two digits (1 and 0) are used in the code.



Step 2: Distribute the activity sheets and review the introduction. If you wish, copy the code from one of your sample envelopes onto the board. From your example, lead students through the decoding process before they begin decoding the ZIP + 4 on the activity sheet. (**Answer:** The number is 20170-4947.)

Step 3: If there is time, students can encode their own ZIP or ZIP + 4. Or, they can do this on their own at a later time. To check their work, they can compare their code to the one that appears on any first-class envelope that comes to their home.

Activity 3

Taking Flight

Goal: To understand how the shape of an airplane wing makes it possible to fly

Time Required: This activity is **self-directed and designed to be completed at home**. The basic activity will take approximately one hour.

Materials Needed

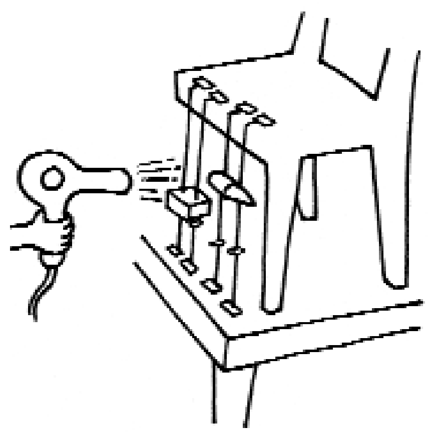
- 1 copy of the take-home activity master per student

Objectives

Students will:

- Experiment with the effect of wing design on lift to consider how an airplane can fly
- Be encouraged to learn more about the four forces that affect flight and design a model airplane (for older students)

Steps: Distribute one activity sheet to each student to complete at home. Explain that the activity deals with lift, one of the four forces that affect flight. The activity sheet includes instructions for creating two wing designs—a box wing and an airfoil wing. Students of all ages can make the wings and see how well each design works. Review with students the illustration to the right that shows how to position the wings to test them. Older students can challenge themselves to do some research to learn more about all four forces of flight and to build their own model airplane.



ENGINEERS IN THE CLASSROOM

Activity 1
Reproducible Master

Hot Wheels!

Goal: To gain hands-on experience in working, as engineers do, with **forces of motion**

Introduction: There are lots of jobs for engineers in the transportation industry. Engineers focus on everything from design, to electrical systems, to hydraulics, to fuel systems, to testing, to the function of the operator controls, and more.

In this activity, you will make a very simple **prototype**, or model, of a car—just like an engineer would—to test the strengths and weaknesses of a new design.

Instructions: Follow the steps below to engineer your own car. The step numbers are also shown on the diagram. You won't have to worry about fuel, though, because this car is powered by a rubber band!

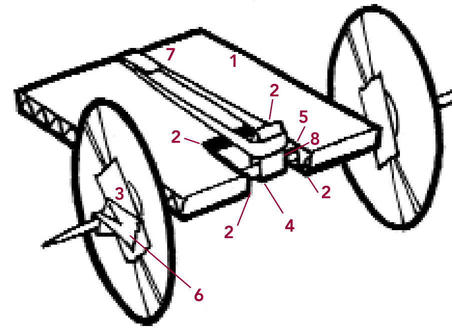
Step 1: Cut a rectangle approximately 5 x 6 inches (12.7 x 15.24 cm) from a piece of medium-weight corrugated cardboard. Cut your rectangle so the holes in the cardboard are visible along the 6-inch (15.24-cm) side. This is your **chassis**.

Step 2: Using a ruler, create a rectangular notch by first marking the center point on one of the 5-inch (12.7-cm) sides of your chassis. Next, make a mark 1 inch (2.54 cm) on either side of the center point. Now, make a dot 1½ inches (3.81 cm) in from each edge mark. Use your ruler to draw a line connecting the 1-inch marks with the 1½-inch dots. Finally, cut along the line to create a 2 x 1½-inch (5.08 x 3.81-cm) notch in the end of your chassis.

Step 3: Cover each side of the hole in one of the CDs or DVDs with a small piece of duct tape. Repeat this process three times to reinforce the duct tape. Then use the skewer to poke a hole through the middle of each CD/DVD. Repeat the process for the other CD/DVD.

Step 4: Measure and mark the center point of your skewer. Slide the skewer through the holes in the cardboard on each side of the notch, about ¼ inch (.64 cm) from the front edge. This is your **axle**.

Step 5: Align the center point of your skewer with the center point of your cardboard chassis. Cut 5 small strips (about ½ inch or 1.27 cm wide and about 1¼ inches or 3.18 cm long) from a roll of duct tape. Wrap just the end of the first strip of tape around the middle of the skewer, then fold the tape over on itself to make a tab that is approximately ½ inch (1.27 cm) high. Continue wrapping the tape in this shape until you have used up the strip. Reinforce your tab by wrapping the other pieces of tape on top of one another. (You need to be sure your tab is strong enough to hold a rubber band in place.)



Step 6: Now carefully thread a CD/DVD onto each end of the skewer, leaving about 1 inch (2.54 cm) of space between the CD/DVD wheel and the cardboard chassis. To reinforce the wheel/axle connection on both wheels, wrap a thin strip (approximately ⅓ to ½ inch or .85 to 1.27 cm) of duct tape around both sides of the joint where the CD/DVD and the axle meet, sticking the tape to both surfaces (be sure you keep the tab on the skewer centered within the notch while you are doing this). When everything is stuck together tightly, the wheel (CD/DVD) and axle (skewer) will rotate together. Repeat these steps to attach the second wheel.

Step 7: Using another small strip of duct tape, attach one end of the rubber band to the chassis about ¼ inch (.64 cm) in from the edge at the center of the back end.

Step 8: Hook the other end of the rubber band over the tab you created on your axle, then turn the axle several times to wrap the rubber band around it. As the rubber band becomes taut, hold the wheels to keep it from unwinding, then carefully put your car on a smooth tabletop or uncarpeted floor and watch it go. Experiment by wrapping the rubber band a few more times.

When you turn the axle, you are giving the rubber band **potential energy** (stored energy). When you release the car, the rubber band unwinds, and potential energy is transformed into **kinetic energy** (motion), making the axle spin.

Can you identify some strengths and weaknesses of your prototype? What did you like about how your car moved? What would you like it to do better? Would you like to add more wheels? Use different materials for the chassis or the wheels? Revise your design based on the ideas you have. Then, build it and test it!

Key Terms

- **Axle**—a rod connected to a wheel in such a way that they turn together
- **Chassis**—the part of a motor vehicle that includes the frame, suspension system, wheels, and steering mechanism, but not the body or engine
- **Forces of motion**—a general term for the variety of forces—such as friction, inertia and velocity—that affect an object in motion
- **Kinetic energy**—the energy that a body or system has because of its motion
- **Potential energy**—the energy stored in a body that can be released or converted into other forms of energy
- **Prototype**—an original that serves as the model for later versions

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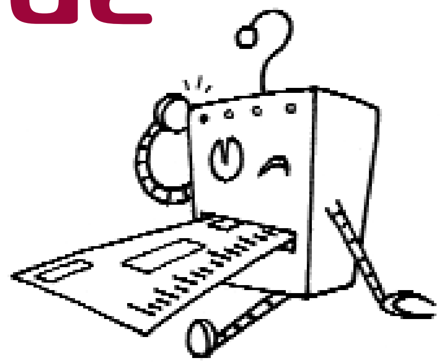
Activity 2
Reproducible Master

Cracking the Code

Goal: To develop a basic understanding of one application of **binary coding**, the basis of all computer operations



Introduction: Have you ever noticed all those lines under the address on the envelopes that arrive in the mail? They're code—like the bar codes on everything you buy—except that this code is your ZIP code. The ZIP code is translated into a bar code so it can be read by a scanner, which is one of the steps in the automated mail-sorting process.

There's quite a bit of engineering involved in that process—from mechanical engineering in the sorting equipment, to systems engineering that puts it all together, to software engineering that develops the software that reads the code. In fact, Lockheed Martin was responsible for developing the software used to sort and efficiently deliver the mail to your home.

How does the Postal Service bar code work? Actually, it's pretty simple. If you look at the example below, you'll see that there are just two kinds of lines—long ones and short ones. The long lines stand for the number 1, and the short lines stand for 0. Grouped into sets of five, these long and short lines, translated into 1's and 0's, can represent all the numbers from 0 through 9, as shown in the chart below. This is an example of binary coding, a code that uses only two symbols. It's the same kind of code that is the basic language of computers.

In this activity, you will learn to decode a ZIP code as well as create the bar patterns for your own ZIP code.

Instructions: Follow these directions to read the ZIP code in the example shown below.

1. To begin, cross out the first bar on the left (the "start" bar) and the last 16 bars on the right (they are part of internal post office coding not related to a specific ZIP code).
2. Beginning with what is now the first bar on the left, draw a line under each set of five bars. (There should be nine sets.)
3. Keeping in mind that long bars equal 1 and short bars equal 0, match the first set of five bars to one of the five-digit numbers in the code conversion chart to find out what number it represents. Write that number under the line you drew.
4. Continue the process until you have decoded the entire nine-digit ZIP + 4 code.

Zip Code Conversion Chart

11000 = 0	01010 = 5
00011 = 1	01100 = 6
00101 = 2	10001 = 7
00110 = 3	10010 = 8
01001 = 4	10100 = 9

To learn more about binary coding, go to **www.tekmom.com/buzzwords/zdbinary.html**

Now, use the chart to create the code for your own five-digit ZIP code, or your ZIP + 4 if you know it.
Write your ZIP code here:____________________________________
Now draw your bar code in this box:

Key Term

- **Binary coding**—a coding system that uses a sequence of only two types of symbols (e.g., 0 and 1) to represent data

Congratulations! You have just mastered one use of binary coding!

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Activity 3
Reproducible Master

Taking Flight

Goal: To understand how the shape of an airplane wing makes it possible to fly

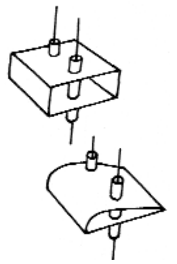
Time Required: Approximately one hour

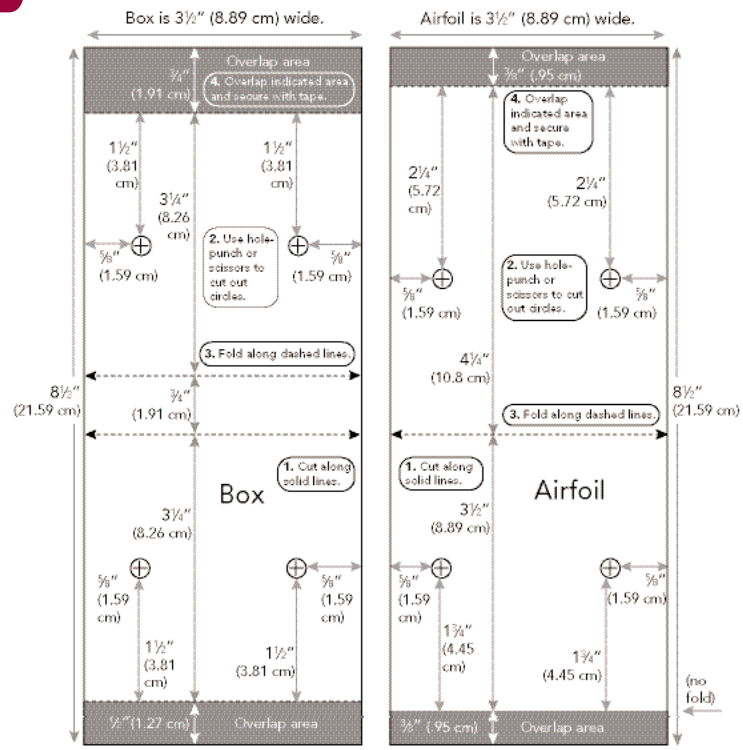
Introduction: You may have noticed that airplane wings have one thing in common: They all have a thicker, curved front that tapers to a point at the back. Do you know why?

In this activity, you will construct two different types of wing shapes—a box and an **airfoil**—and test them to learn how they react in terms of **lift**, one of the four forces that affect flight and how aircraft are engineered.

Materials Needed

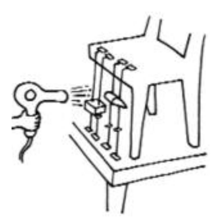
- 1 sheet of plain white 8½ x 11 paper
- Scissors, ruler and pencil
- 2 plastic drinking straws
- 4 regular-size paper clips
- Transparent tape and craft glue
- 4 strings, each 2 feet (70 cm) long
- 1 table and chair
- 1 hair dryer (1,800-watt minimum) and extension cord if needed





Instructions: Using the measurements on the templates provided here, follow the steps below to assemble your two wings. Note that Steps 1-4 are numbered on the template to help guide you. Draw the measurements shown on the template on your paper to create the wings.

1. Cut along the solid lines.
2. Punch or cut out the holes.
3. Fold along the dashed lines.
4. Overlap where noted and secure with tape.
5. Cut each straw in half. Thread each half through one pair of holes as shown. Secure each straw to both sides of the wing with a drop of glue.



6. Put the chair on top of the table, leaving several inches between the chair's front legs and the table edge.
7. Thread a piece of string through each of the four straws. Tape one end of each string to the chair seat and the other to the tabletop so the string is tight. Be sure to space the strings so that your wings can move up and down easily.
8. Clip a paper clip onto each string several inches above the tabletop. The wings will rest on the paper clips.
9. Now you're ready to experiment. Begin with the box wing.

Aim the hair dryer at the wing from several inches away and turn it on with the blower set at "high." You will see that the box wing does not move (fly). Repeat the experiment with the airfoil. As you raise and lower the hair dryer, keeping it pointed at the wing's front edge, you can raise and lower the airfoil. You have made it fly!

Key Terms

- **Aerodynamic**—designed to reduce air resistance, especially to increase fuel efficiency, stability or maximum speed
- **Airfoil**—a shape that creates lift through differences in the flow of air around it
- **Drag**—the force that slows an airplane down as it moves forward
- **Gravity**—the force that pulls objects toward Earth
- **Lift**—the force that enables airplanes to rise from the ground
- **Thrust**—the force that propels an airplane forward

What Happened?

You have just demonstrated that shape affects lift. A scientist named Daniel Bernoulli discovered that if air moves faster over the top surface of an object than it does over the bottom surface, a force is created that tends to lift the object upward. An airplane wing in an **aerodynamic** shape, like that of an airfoil, will force air to move faster over the top than the bottom, creating the lift that is needed to make the airplane fly.

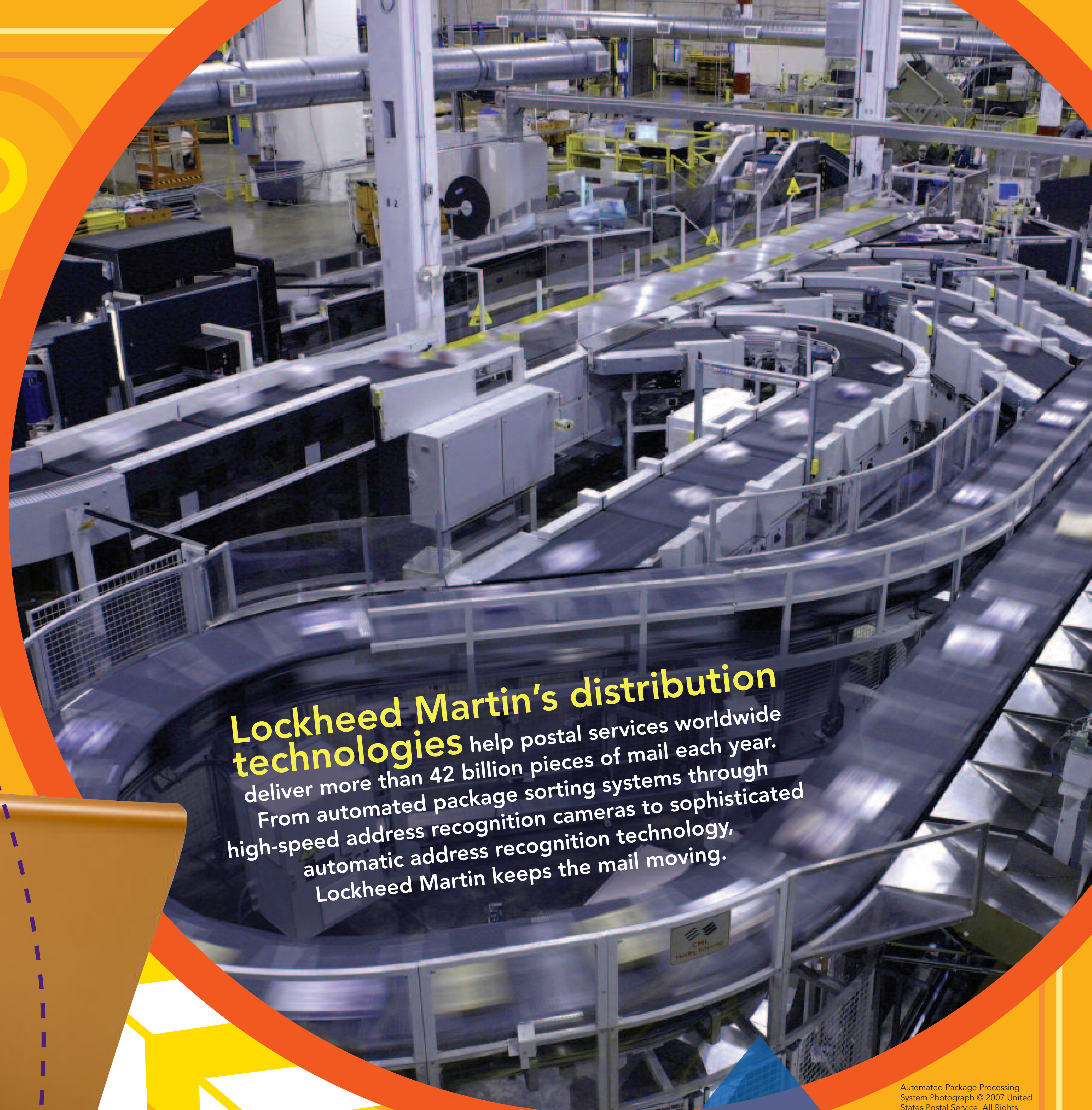
The box-shaped wing could not create lift because both the top and the bottom of the box had the same shape. That shape did not force the air going over the top to go faster, and lift could not be created as a result.

Want to Know More?

1. Find out more about how the shape of a wing affects lift. Check out **http://scifiles.larc.nasa.gov/text/kids/Problem_Board/problems/flight/lift2.html**
2. Do some research to learn how all four aerodynamic forces—**drag**, **thrust**, **gravity**, and **lift**—affect flight. Begin your search at **http://teacher.scholastic.com/paperairplane/airplane.htm**
3. Find out about the different kinds of paper airplanes you can build at **www.paperairplanes.co.uk/planes.php**. Pick a design, build one, and make your own experiments.

ENGINEERS IN THE CLASSROOM

some people say I'm too organized – my clothes, my room, my schedule. But I'm just getting started...



Lockheed Martin's distribution technologies help postal services worldwide deliver more than 42 billion pieces of mail each year. From automated package sorting systems through high-speed address recognition cameras to sophisticated automatic address recognition technology, Lockheed Martin keeps the mail moving.

I Want to Be a Systems Engineer!

My name is **Allison Higgins** and I *am* a systems engineer. I work at **Lockheed Martin**, pushing our **postal processing systems** to deliver faster than ever before.

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We never forget who we're working for®

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