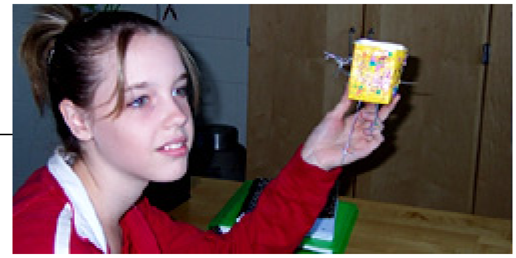
Session 5

Making Machines

Engineering Fundamentals



Making Machines really puts things in motion. In *5A: Design, Build, Make It Go*, make a rolling toy from a set of everyday materials in a mini-design challenge, and then discuss your experiences with how energy is transferred. To understand that most machines are made of many smaller machines, study the component machines in a lawnmower through a Web-based tutorial, in *5B: Not-So-Simple Machines*. Participate in a mini design challenge to create a simple machine. The activity *5C: Gears, Cranks, Crankshafts, and Belts* is an exploration of gears, cranks, crankshafts, and belts, and culminates in the design, conceptual drawing, and initial construction of a mechanical toy. As a Home Improvement activity, *Build a Mechanical Toy*, take your plans and materials home and finish your toy.

Design, Build, Make It Go!

Handout: Session 5, Activity A

Make a Rolling Toy Design Challenge: Using any or all of the materials in your kit, make a rolling toy that travels 3-5 feet (1-1.5 meters) on its own power. (It does not need to go in a straight line.)

If you get stuck along the way, here are some hints:

- Consider a windup toy. How does it work? Take a look at some toys that store and release energy to produce some kind of motion.
- Windup toys convert potential energy into kinetic energy as they unwind.
- How is the energy stored and released? (Often this is a spring.)
- What could be used instead of springs to store and release energy?

Slinky

Reading: Session 5, Activity A

Patented by Richard James, Upper Darby, Pennsylvania for James Industries. Filed 1 November 1945 and published as GB 630702 and US 2415012.

This is the familiar toy which consists of coils that move downstairs, along the floor, or from hand to hand. Richard James was a mechanical engineer working for the U.S. Navy. While he was on a ship undergoing trials, a lurch caused a torsion spring to fall accidentally from a table to the floor. Its springy movement made him think. When he saw his wife Betty that night he showed her the spring and said, "I think there might be a toy in this." Two years of experimentation followed to achieve the right tension, wire width, and diameter. The result was a steel coil with a pleasant feeling when handheld, with an ability to creep like a caterpillar down inclined planes or stairs, and an interesting action when propelled along the floor. Betty came up with the name of Slinky*, from slithering.

James managed to persuade Gimbels, the department store, to give him some space at the end of a counter. He would demonstrate the toy and hope to sell some of his stock of 400. It was a miserable November night, and Betty and a friend were on hand to buy a couple to encourage sales. They never had the chance, as crowds gathered around and the entire stock went in an hour and a half. A company, James Industries, was set up to make the product. A machine was devised which coiled 24 meters in 10 seconds. The price for a Slinky was $1 in 1945, which had increased to $2 by 1994. More than 250 million have been made, with some variations, including brightly colored plastic models. The only substantial change in the design is that the end wires are now joined together to prevent loose wires damaging, for example, an eye. The trademark was registered in the United States in 1947 and in Britain in 1946.

Besides the obvious fun possibilities, the toy has been used by science teachers to demonstrate the properties of waves. NASA has used them to carry out zero gravity physics experiments in the space shuttle. And in Vietnam, American troops used them as mobile radio antennae.

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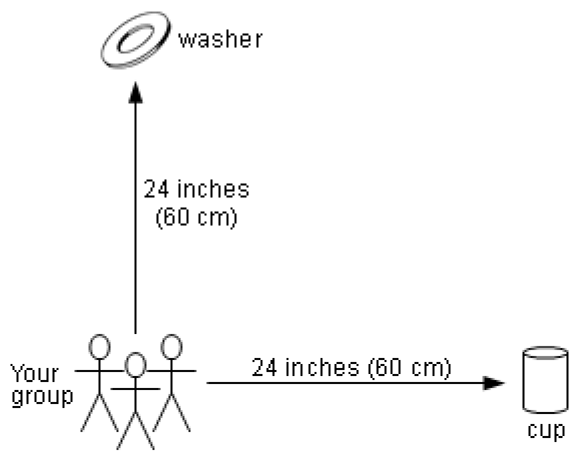
Van Dulken, Stephen. *Inventing the 20th Century, 100 Inventions That Shaped the World*. New York: New York University Press, May 2002. www.nyupress.nyu.edu*

Not-So-Simple Machines

Handout: Session 5, Activity B

Use what you know about simple machines to create a solution to the following design challenge.

Design Challenge
Using at least one simple machine, design and construct a device that can move a washer that is placed 24 inches (60 cm) away from your group, 90 degrees, to a cup that is also placed 24 inches (60 cm) away. See diagram below:



Design Requirements

- Each group must use at least one simple machine in the device they build.
- The washer must be moved from its location to the fixed location of the cup without direct contact from any student.
- You may use only the materials provided.

As you go through the design process, think about:

1. What problem is being solved?
2. Which simple machines can be used to solve the problem?
3. What process will you go through in order to design a solution?

Be prepared to share your design solution.

Meet a Mechanical Engineer

Reading: Session 5, Activity B

Alma Martinez Fallon
Northrop Grumman Newport News

Mechanical engineers help to shape nearly everything in the built environment, but their impact on communities isn't always visible. "Anything that moves, heats, cools, rotates, or flies, there's a mechanical engineer involved in it," says Alma Martinez Fallon. She engineered mechanical systems in support of nuclear submarines and aircraft carrier design before moving into management ranks at one of the nation's largest shipbuilders, Northrop Grumman Newport News. Although mechanical engineers are involved in the design and production of everything from cars to power plants to refrigerators, she adds, "the only time most people hear about engineers is if something fails."

As president of the Society of Women Engineers and an active member of the American Society of Mechanical Engineers, Fallon is helping to make sure that more young people know what engineers do and why the field offers a world of opportunities.

How She Got Interested

Fallon excelled at mathematics through high school, "but I didn't know where I could apply my skills, other than to teach." She didn't know any engineers in her neighborhood of Queens, New York, where her parents settled after immigrating from the Dominican Republic. And she didn't want to be a teacher.

Fallon says she took a "nontraditional path" into her profession. She worked full-time after high school and didn't return to college until age 25. By then, she had met some professional engineers who encouraged her to apply her interest and aptitude in math to an engineering degree.

At Old Dominion University in Norfolk, Virginia, she was one of a handful of women in her engineering classes. She was drawn in by the subject, as well as the chance to "give back to the community. Engineering touches everything. It's been a great fit for me," she says. "I like the practical side of applying math and science to problem solving. I was hooked right away."

5B Reading: Meet a Mechanical Engineer (continued)

Entering the Profession

To help pay the bills during college, Fallon took advantage of an opportunity to combine her studies with work experience. While still an engineering student, she began to learn about shipbuilding design and construction. The practical experiences shaped her course selection, and she decided to focus her undergraduate studies on mechanical engineering. When she graduated, Newport News offered her a position as an associate engineer, working on the design and engineering of *Seawolf* class submarines.

Before long, Fallon was discovering what many mechanical engineers find rewarding about their work. "Designing something and seeing it work—getting to see it run on a ship—that's a lot of fun," she says. Fallon's initial plan was to stay at the company for a few years to gain a solid technical foundation. Instead, she found herself moving up through the engineering ranks and into management. She also expanded her skills by earning a master's degree in engineering management from George Washington University. Now a 15-year veteran of Newport News, she manages a group of about 100 engineers, planners, and analysts involved in planning and manufacturing engineering.

Applying Diverse Skills

As a manager, Fallon draws on a wide range of skills, not all of them taught in engineering school. "You have to be able to communicate, to be strategic, to motivate people. You have to help excite the organization, move the goals and objectives forward, and provide results. It's different from what an engineer learns in school," she admits, "but I use my engineering training to work through the organization as a leader."

What does she like best? "The ability to develop people, to help them grow as individuals. That's number one. Also, I'm results oriented. My area can take on a difficult problem, and seeing it through to resolution and implementation can be very rewarding."

Advice for Students

For students thinking about a future in engineering, Fallon has some specific advice: "Stick to your math and science." In addition, she suggests looking for "programs outside of class that can expose you to career choices in the area of math and science." In her own career, she can see the value of mentors. "During my time at Newport News, I have found individuals who have taken an interest in supporting me." Now she has moved into the mentor role, helping young engineers as they enter the profession. Today's students can take advantage of online opportunities, she adds, no matter where they live. "Through e-mentoring, you can find a mentor who's interested in helping you."

The future looks bright for students who pursue mechanical engineering as a career, Fallon says. "Demands of the workplace continue to increase, especially as technology continues to be enhanced," she says. "Anything that moves, anything that involves heating or cooling, anything that generates power, there's a need for mechanical engineers to design and produce

5B Reading: Meet a Mechanical Engineer (continued)

it. The demand is going to be there."

In her role as president of the Society of Women Engineers, Fallon is an advocate for improving the number of women entering the field. Although women account for only about 20 percent of engineering school graduates, "some universities are doing very well. We want to understand why," Fallon says, and then find ways to build on that success.

Gears, Cranks, Crankshafts, and Belts

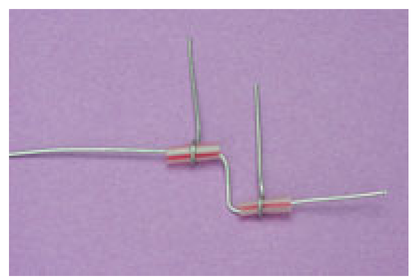
Handout: Session 5, Activity C

Make a Crankshaft Device
Do you remember playing with jack-in-the-box toys when you were small? They have a crank mechanism something like the toy you will make today. With this crankshaft toy, you will see how the direction of a force can be changed mechanically. Turning the crank around and around makes other parts go up and down!

Supplies

- Small box (8 oz. milk carton will do)
- 3 pieces 16-gauge steel wire: one 8" (20 cm) length, two 3" (7.5 cm) lengths
- 1 straw
- Electrical tape or long bead (for crank handle)
- Needle-nose pliers

Steps



1. Cut off the top of a milk carton to make a small box with one side open.
2. Turn the box so the opening is on the table, and drill or poke a hole toward the top third of the box at the same height on opposite sides.
3. Drill or poke two holes in the top, about an inch or 2 1/2 centimeters apart. They should be in a straight line with the other two holes.
4. Cut two short pieces of straw about 1/3 the width of the box.
5. Wrap the end of one of the small pieces of wire around one piece of straw. Tighten the wire so that it pinches the straw while allowing for another wire to pass through. Repeat with the other wire and straw.
6. Take the long wire; make two 90-degree bends, an inch or 2 ½ centimeters apart, leaving one side slightly longer than the other. The longer end becomes the crank handle.
7. Thread a straw with wire attached onto each end of the wire to the bend.
8. At the outside of each straw, make another 90-degree bend, making a “U” with the center section.
9. Find the halfway point of the center section of wire between the straws. Using this as a guide, bend the outer wires away from the center at that point.

5C Handout: Gears, Cranks, Crankshafts and Belts (continued)

10. From the inside of the box, place the crack handle end of the wire through one of the side holes.

11. Reach into the underside of the box and gently turn the smaller wires so they poke through the holes in the top of the box.

12. Place the other end of the wire into the other hole. You may need to bend this and then re-straighten. Make a bend in the wire to secure it on the outside of the box.

13. Bend the crankshaft end to make a handle. Secure a large bead or electrical tape on the crank to finish the handle.

Crank the handle and watch the wires go up and down. It may need some adjustment to get the best motion. Now it's all up to you! How will you turn the up-and-down motion into something fun?

Design A Mechanical Toy

Handout: Session 5, Home Improvement

Your mechanical toy can be as unique as you want it to be. Spend some time planning the toy and then finish making the toy at home. Plan your mechanical toy in your design notebook.

1. Describe your toy's function. What would you like it to do? How will it do this?
2. Draw your plans for your mechanical toy.
3. Spend time fine-tuning the device so it works reliably.
4. Add fun elements to turn it into an eye-grabbing plaything.
5. Bring it in the next day for everyone to enjoy!