EDUCATOR'S GUIDE

PBS

DESIGN SQUAD™

10 ENGINEERING CHALLENGES FOR 9- TO 12-YEAR-OLDS

DESIGN SQUAD: INSPIRING A NEW GENERATION OF ENGINEERS

Dear Educators,

Intel welcomes you to the new reality-based PBS series, *Design Squad*™! Our sponsorship is the newest component of our Intel® Education Initiative, which is committed to twenty-first century teaching and learning through the effective use of technology and excellence in mathematics, science, and engineering.

Design Squad's substantive focus on math, science, and the design process sparks young people's curiosity about the world and hones their problem-solving skills. By showcasing engaging, real-life applications of engineering, we believe that *Design Squad* will increase their interest in the subject. Engineering will be presented as the creative career we know it to be, enabling young viewers and participants to turn science into reality.

We encourage you to use the *Design Squad* Educator's Guide—in concert with the television series and the Web-based outreach components—to help young people investigate and solve challenging problems. The goal is to pique the next generation's interest in engineering as a career, and in science and mathematics as the fascinating means to intriguing ends. The ripple effect you create will change lives.

Sincerely,

Brenda Musilli
President, Intel Foundation

Photo: Webb Chappell

Design Squad makes engineering exciting and empowering by having kids work together and use their ingenuity to solve problems and build things.

WHAT'S IN THIS GUIDE

This guide has everything you need to bring engineering to life for kids aged 9–12 in your afterschool program or classroom. The guide's ten hands-on challenges emphasize teamwork and creative problem solving. From the Leader Notes to the Discussion Questions to the Challenge Sheets, you have what you need to unleash your kids' ingenuity and to get them thinking like engineers.

FIND SOMETHING TO FIT YOUR SCHEDULE

- **Do one meeting:** The first challenge of each unit is stand-alone. Choose any one of these.
- **Do most of a unit:** Both *It's Electric* and *Cars, Cars, Cars* have three challenges, but you can do just Challenges 1 and 2.
- **Do a full unit**: Each unit is self-contained and doesn't depend on the work done in other units. However, once you start a unit, do its challenges in sequence, because later challenges build on earlier ones.

1 Meeting
Challenge 1 of any unit

2 Meetings
Challenges 1 & 2 of Unit 1 or Unit 2

2–3 Meetings
1 full unit

4–8 Meetings
Several units

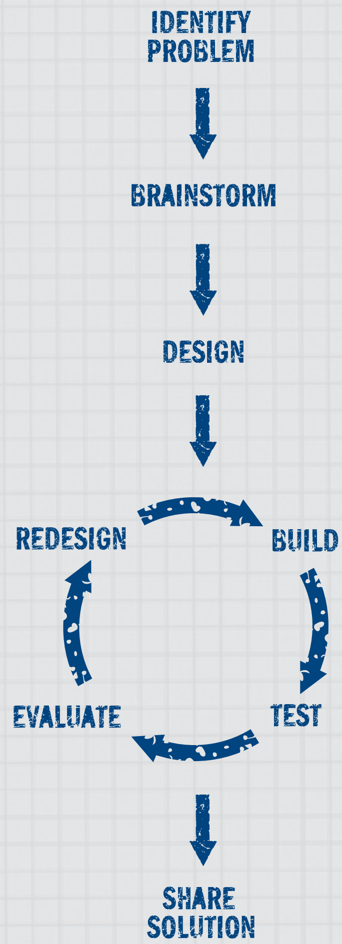
10 Meetings
All 4 units

You can find a combination of activities that's just right for your group. Each challenge takes an hour.

INTRODUCING THE DESIGN PR

When engineers set out to solve a problem, their first solution is rarely their best. Instead, they tinker, try different ideas, fail, learn from mistakes, and try again. The series of steps engineers use to arrive at a solution is called the design process.

You can approach almost any problem using the steps of the design process—it's a great way to come up with lots of ideas, improve a design, and learn from mistakes. In fact, the design process is something people use every day—planning an outing, writing a letter, making breakfast, or doing any task where they create something that did not exist before.



Engineers follow the steps of the design process as they work through a problem.

REINFORCING THE DESIGN PROCESS WITH YOUR KIDS

- As kids progress through a challenge, point out which step of the design process they are doing.
- Engineers communicate visually as well as verbally. Have kids keep design notebooks to record and sketch their ideas and results.
- Try every challenge yourself before doing it with kids. This will help you anticipate where kids might need assistance, and you'll be prepared to respond to questions that might come up.
- When something fails, encourage kids to try again. They'll come up with lots of interesting solutions and learn from their mistakes.
- Avoid giving too much direction; it discourages kids from thinking for themselves. Answer questions by asking a question back. This helps kids discover their own answers. (See examples below.)

QUESTIONS FOR GUIDING KIDS

To help a child...	Ask...
Stay focused on the activity	"What do you need to do now?" "How does your idea work?"
Answer his/her own question	"That's an interesting question, how can we find out?" "Why do you think this happened?"
Problem-solve or try another approach	"Is there another way to look at this?" "Why do you think this is happening?"
Make connections to the real world	"What does this remind you of?" "What are other examples where this happens?"
Improve his/her design	"Could you change something to make it work better?" "What else would you like to try?"

(Adapted from Harlen, Wynne, (ed.), *Taking the Plunge: How to Teach Primary Science More Effectively.* Portsmouth, NH: Heinemann, 1985. Also from "Putting Girls at the Center in Math, Science and Technology." © 2003 Girl Scouts of the USA. Used with permission.)

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KIDS CHALLENGE SHEETS REINFORCE THE DESIGN PROCESS

The different parts of each Challenge Sheet are clearly labeled with the different steps of the design process. After completing a few challenges, kids will begin to see that the design process is a way to think creatively about a problem and work it through, from beginning to end.

LEADER NOTES REINFORCE THE DESIGN PROCESS

The steps of the design process offer a framework for the Leader Notes, which always use the three sections described below to help you reinforce the design process for kids throughout a challenge:

1. **Introduce the challenge, brainstorm, and design.**
Before building, engineers define the problem they want to solve and come up with a variety of solutions—the more, the better. At the start of every challenge, provide a few minutes for kids to individually brainstorm solutions, jot notes, and sketch possible designs in their notebooks. Then have them share their ideas and brainstorm as a group. List their ideas on chart paper or a board and refer to them later during the redesign phase.

2. **Build, test, and redesign.**
Once kids finish the brainstorm, have them settle on a design idea to start with. It's unlikely that kids' first solutions will be their best, and as they build, they'll need to refine their ideas and solve problems that come up. At the heart of the design process is the attitude that "if at first you don't succeed, try, try again." The design process offers kids a structured way to take an idea from its initial to its "finished product" stage, learning from mistakes they make along the way.

3. **Discuss what happened.**
Engineers present their work to colleagues to show how they solved a problem. This way, they learn new ideas and approaches from each other. At the end of each meeting, have kids show each other what they built and talk about how they used the design process to solve the challenge. Also, point out interesting solutions and examples of creative thinking and effective teamwork. If applicable, mention how much progress the group has made over the weeks. Get excited and congratulate them on a job well done.

Photo: Lauren Feinberg

WHAT'S ENGINEERING?

"*Engineers get to imagine the future and design for it.*"
–Marisa Wolsky, *Design Squad* Executive Producer

"*Engineering prepares you with the basic skills to tackle any problem.*"
–Alba Colon, NASCAR engineer

"*Engineers create new products and new systems that improve people's lives and meet the needs of society.*"
–Heidi Nepf, Professor of Engineering

[Design is] "*...not just what it looks like and feels like. Design is how it works.*"
–Steve Jobs, Innovator
New York Times, 11/30/03

SETTING UP A DESIGN SQUAD

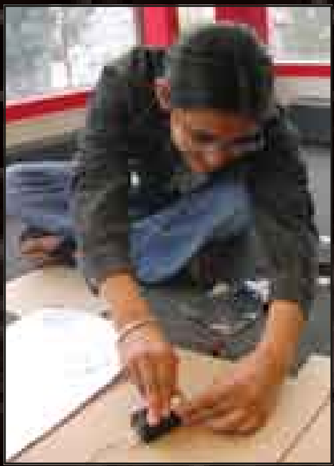


Photo: Lauren Feinberg

OLDER KIDS LOVE *DESIGN SQUAD* CHALLENGES, TOO

Design Squad activities appeal to anyone who loves using his or her ingenuity to tackle open-ended challenges. Consider starting a club for older kids who may be aging out of your afterschool program.

In a *Design Squad* club, you can use the guide's ten hands-on challenges to show kids how interesting and exciting engineering is. Kids practice important skills, such as problem solving, teamwork, critical thinking, and creativity—skills and attitudes you already promote in your program. You can run a *Design Squad* club just about anywhere. All you need are a large room, some tables, and some low-cost materials. The resources in this guide and on the Web site make it easy to facilitate the challenges and engage kids in engineering.

STARTING A DESIGN SQUAD CLUB STEP-BY-STEP

1. **Recruit club members.**
   - Create a "Coming Soon" bulletin board and post a flier about the club.
   - Advertise the club in your organization's newsletter. Use language from this guide to describe the show and the challenges that kids will do. Tell families how to sign up their kids.
   - Determine the number of kids you feel comfortable managing (we suggest 8 to 12 per leader). If more sign up, get more leaders, divide the club into two sessions, or keep a waiting list for the next time you offer a club.

2. **Schedule the dates and arrange a meeting place.**
   - Decide how many weeks your club will meet and the duration of each meeting. Then select and reserve a space that has ample room and tables for materials. A place to store kids' work is also helpful.

3. **Give your room a *Design Squad* club look and feel.**
   - Download the *Design Process* sign from the Web site and hang it in your clubroom.
   - Make a bulletin board and post photos and examples of the challenges so others can see what goes on at *Design Squad* club meetings.

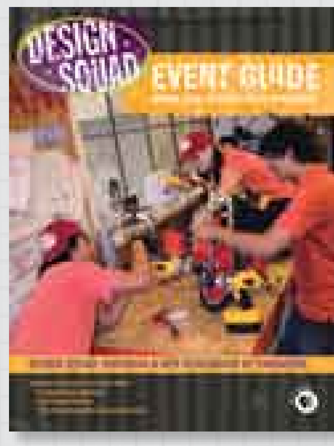
4. **Partner with an engineer.**
   - Invite engineers to visit your club to talk about everyday examples of engineering and discuss the challenges' engineering principles. They can also act as role models and introduce kids to career options. To find volunteers, contact local universities and colleges with engineering programs. Also try manufacturing plants and public works and water departments. In addition, the *Design Squad* and www.eweek.org Web sites list engineering societies that can recommend potential partners.
   - Show kids the D Squad Pro Files of engineers. In these clips, engineers talk about how they became interested in engineering and the rewards of being an engineer. Download the clips from the *Design Squad* Web site at pbskidsgo.org/designsquad/engineers.

RESOURCES TO HELP YOU LEAD ENGINEERING CHALLENGES

Web

Download the following resources for your engineering club, program, or event from the *Design Squad* Web site at pbskidsgo.org/designsquad/engineers:

- **Design Squad *Event Guide*.** Spark kids' interest and confidence in engineering by hosting a lively, fun-filled event, such as a family night or science and engineering day. To help you plan and organize your event from beginning to end, the Event Guide provides you with an event checklist, reproducible challenge sheets for five challenges, and an evaluation form.
- ***Video clips*.** Show kids a brief clip about the show, D Squad Pro Files of engineers, and animations that demonstrate the show's science and engineering principles.
- ***Challenges in Spanish*.** The five Event Guide challenges are available in Spanish and English.
- ***Iron-on* Design Squad *logo transfers*.** Make *Design Squad* T-shirts for yourself and your kids.
- ***Design Process sign*.** Hang this sign in your room to help set the tone and to refer to during a challenge.



Professional Development

- ***Attend a* Design Squad *training*.** We're hosting a series of nationwide trainings for engineers and informal educators on ways to connect kids to engineering. A training will help you find engineering partners, give you tips on doing challenges with kids, and provide ideas for introducing your colleagues to engineering. To learn more, contact *Design Squad*'s Outreach Coordinator at *designsquad_feedback@wgbh.org*.
- ***Sign up for the* Design Squad *e-newsletter*.** Get updates on the show, Web site, trainings, and resources. To sign up, visit the *Design Squad* Web site at *pbskidsgo.org/designsquad/newsletter*.

SOURCES FOR MATERIALS

To make your session run smoothly, collect and prepare materials for the challenges ahead of time. All of the materials in this guide can be found at local electronics, hardware, craft, grocery, and office supply stores. For large quantities or online sources, try these Web sites:

Battery holders
We like: single AA cell holders with wire leads
Item #BCAA
65¢ each
Batteryspace.com

We also like:
AA battery holder
Item #270-401
99¢ each
Radioshack.com

Bulbs
We like: 1.5 volt, screw
Item # EL-LAMP1.5
50¢ each
Hometrainingtools.com

We also like:
1.2 volt, screw
Item #272-1174
$1.59 for two
Radioshack.com

Bulb holders
We like: single bulb lamp base
Item #EL-BULBHD1
90¢ each
Hometrainingtools.com

We also like:
Item #272-357
$1.69 each
Radioshack.com

Buzzers
We like: two-wire lead buzzers
Item #KPI-2210L
$1.00 each, minimum order of 50 (reference code *WGBH SQ2124200* with order)
APC International
570-726-6961

For a louder buzzer:
Item #273-053
$3.29 each
Radioshack.com

Chipboard
We like: 11 x 17 inch
Item #S-8293
$49 per case (375 sheets)
Uline.com

Compact discs
Collect used CDs and DVDs or purchase new
Item #01-VDPD801-100
$15 for 100
Thetechgeek.com

Corrugated cardboard
We like: 11 x 17 inch
Item #S-3585
28¢ per piece
Uline.com

Electrical wire
We like: stranded, 22-gauge
Item #278-1224
$5.99 for 75 feet
Radioshack.com

Faucet washers
(Both flat and beveled work)
We like: $\frac{1}{4}$ inch Large
$1.19 for card of 10
Doityourself.com/invt/4001095

We like: $\frac{3}{4}$ inch to 1 $\frac{1}{8}$ inch (the larger, the better)
$4 for 10
Doityourself.com/invt/u116076

Metal washers
We like: zinc-plated Cut or Fender washers
Offer a variety of sizes
Approx. 5–10¢ each at hardware store

Motors
We like: regular motor with pinion attached
Item #RM3 with plastic pinion
$2 each
Solarbotics.com

We also like:
1.5 to 3-volt metal-gear motor
Item #273-258
$3.29 each
Radioshack.com

Ping-Pong balls
Martin Kilpatrick brand
144 One Star balls
$36 for 144
Nationaltabletennis.com

Poster or mounting putty
We like: Duck Brand
Item #07014884
$1.49 for 2 ounces
Officemax.com

Wooden skewers
We like: Good Cook brand ($\frac{1}{8}$-inch diameter)
Item #07675324451
$1.29 for 100
Netgrocer.com

Wooden spools
We like: hourglass shape
1 $\frac{3}{8}$ inch diameter by 1 $\frac{15}{16}$ inch long with a $\frac{5}{16}$-inch hole
Item #NS28
$1.80 for package of 10
Woodcrafter.com

Note: Although these sites were verified at the time of publication, Web site addresses and content are subject to change.

If you are buying small quantities, try these types of stores:

- **Electronics:** electric wire, buzzers, compact discs, motors, bulbs, bulb holders, battery holders
- **Hardware:** beveled faucet washers, faucet washers, metal washers, paint stirrers, wooden dowels
- **Craft:** wooden spools, Popsicle sticks, wooden dowels
- **Grocery:** wooden skewers
- **Office:** corrugated cardboard, chipboard, poster putty
- **Sporting Goods:** Ping-Pong balls, golf balls, tennis balls

Photo: Lauren Feinberg

HIDDEN ALARM

THE CHALLENGE: Build a battery-operated buzzer system so small that it's easy to hide and use to surprise people.

In this challenge, kids (1) learn about circuits; (2) make a handheld alarm that buzzes whenever the circuit is closed; and (3) use the design process to debug problems. This work will prepare kids to build and test a dance pad (basically, a large version of the handheld alarm) in the next two challenges of this unit.

1. **Introduce the challenge, brainstorm, and design.** (15 minutes) Tell kids the challenge for today and begin by asking:
   - How can you get this buzzer to work? (*Connect it to a battery. NOTE: The buzzer only works when it is properly connected to the positive and negative ends of the battery (i.e., red wire to the positive terminal and black wire to the negative terminal). If it doesn't work, reverse the wires. Show kids that one way of connecting the wires to the battery terminals works, while the other way doesn't.*)
   - How can you turn your alarm on and off? (*Make a switch to open and close the circuit.*)
   - How can aluminum foil, wire, and cardboard be useful in building the alarm? (*Metal, such as the foil and wire, conducts electricity. If you connect a wire to foil, the whole piece of foil will conduct electricity and act like a big wire. Cardboard is stiff and can be used as a base. When folded, it can flex and act like a spring, which is handy when you are making a switch to open and close a circuit.*)
   - Let's brainstorm some designs. Where could you hide an alarm and how might you design it to surprise a friend? (*Kids could connect it to a chair or hide it in their hands or clothing. They would need to figure out how to make a switch and how best to mount the parts. Have kids sketch their ideas in their design notebooks.*)

2. **Build, test, and redesign.** (30 minutes) Distribute the challenge sheets and have kids begin building. During the activity, help kids debug the following common issues:
   - The buzzer doesn't work. *Make sure the wires are connected to the correct battery terminals. Also, check for open connections that would cause an incomplete circuit.*
   - The switch doesn't work reliably. *A switch starts and stops the flow of electricity by opening a gap in the circuit. Kids can manually move a wire to open and close a circuit. Or, they can attach wires and foil to different sides of a piece of cardboard and use the spring action of folded cardboard to open and close the circuit.*

3. **Discuss what happened.** (15 minutes) Have the kids show each other their alarms and talk about how they solved any problems that came up. Emphasize this challenge's key themes—circuits, switches, and debugging—by asking questions such as:
   - How could you tell electricity was flowing through your alarm? (*The buzzer buzzed.*)
   - Why is a switch useful in a circuit? (*It lets you control when electricity flows in a circuit.*)
   - What are some examples of when you had to do something a few times to get your alarm to work the way you wanted?
   - What would you do differently if you had more time?

Photo: Lauren Feinberg

CHALLENGE 1

HIDDEN ALARM

DESIGN SQUAD

YOUR CHALLENGE

Make your friends and family ask, "What's buzzing?" Design an alarm that you can turn on and off and that is small enough to hide.

MATERIALS*

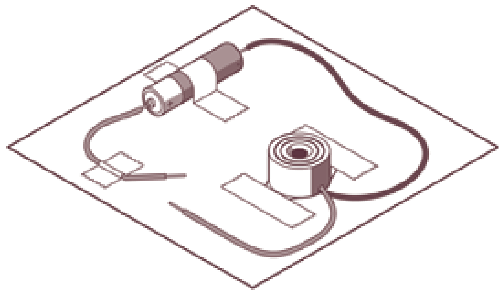
- 1 AA battery
- AA battery holder (optional)
- Aluminum foil
- 1 buzzer (preferably one with wires attached)
- 1–2 feet of electrical wire (22-gauge works well. Ask an adult to help you strip the plastic coating off the ends to expose the wire.)
- Scissors
- Tape (duct or masking)
- Thin cardboard (non-corrugated, such as chipboard, oaktag, or paperboard from cereal boxes)
- Wire strippers

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

BRAINSTORM AND DESIGN

Before you begin designing, brainstorm answers to the following questions and record your ideas in your design notebook.

- Where do I want to hide my alarm?
- How small does it need to be to fit in my hiding place?
- How will I turn my alarm on and off?

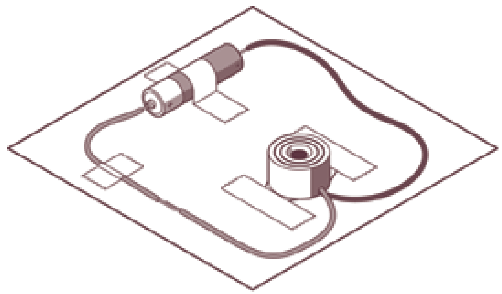


Open circuit

BUILD, TEST, AND REDESIGN

A ***circuit*** is a path along which electricity can travel. In a ***closed circuit***, all the parts are connected and the electricity flows uninterrupted from the battery to the buzzer and back to the battery. In an ***open circuit***, some parts are disconnected, and the gap prevents electricity from flowing.

Build your design and test it. Did your alarm buzz on command? Did it fit in its hiding place? Did you trick anyone? When we made ours, we had to debug some problems. For example, our buzzer didn't work at first, and it took some tweaking to get the switch to turn on and off reliably. If things like this happen to you, figure out a way to fix the problem so that your alarm works every time.



Closed circuit

TAKE IT TO THE NEXT LEVEL

- Make your alarm even smaller.
- Change your alarm to fit into a different kind of hiding place.

INSIDE THE ENGINEERING

SMALLER AND BETTER

Maybe the best things DO come in small packages! The first computer, called the Electronic Numerical Integrator and Computer (ENIAC), was built in the 1940s (not so long ago, really). It was so big it filled a small building and weighed 30 tons! Since then, engineers have been making computers smaller and smaller and smaller. Today, the average laptop computer weighs just six pounds. That means ENIAC weighed as much as 10,000 laptops. We don't even want to think about carrying all those around. On top of that, today's laptops are even more powerful than ENIAC. How'd they do it? By making the parts much, much smaller and much, much faster. Just think, ENIAC, laptops, and the alarm you made work in the same basic way—by switching circuits on and off.

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

TAKE IT ONLINE

Want a jolt? Build your own circuits and diagram them! Download *Basic Electrical Concepts in a Flash* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

The *Design Squad* cast hit the dance floor. They used circuits to design and build a sound and light show that went along with a dance routine given them by a hip-hop artist. Cast members used wireless sensors to activate the lights as they danced.

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Design Squad is produced by WGBH Boston. Design and engineering consulting services provided by Continuum.

LEADER NOTES FOR CHALLENGE 2

DANCE PAD MANIA

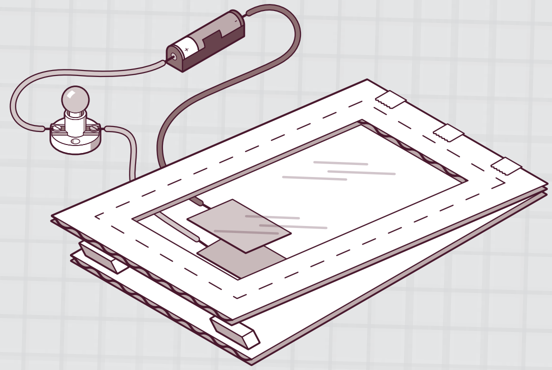
THE CHALLENGE: Build a dance pad that lets kids use their feet to sound a buzzer and flash a light.

In this challenge, kids build a large-scale version of the alarm they built in Challenge 1. To do this, they (1) build a large pad that has a battery-operated buzzer or light bulb; (2) create a switch that's operated by their feet; and (3) develop a sturdy design than can withstand continuous pounding. In the next challenge, kids use their pads to play a game that gets them thinking about designing a product to survive rugged treatment.

1. **Introduce the challenge, brainstorm, and design.** (10 minutes) Tell kids the challenge for today and begin by asking:
   - How do dance pads, such as Cyber Groove™, Dance Dance Revolution®, Feet of Fury™, or "Pump it Up"®, work? (*A dancer stands on a floor pad with a grid printed on it and watches a screen, which tells him or her which grid square to step on. The screen gives the dancer a series of steps to complete, and a computer scores how accurately the dancer does the moves.*)
   - What are the important parts of these kinds of pads? (*Wires, switch, battery, screen, computer, buzzer, and lights*)
   - What did you learn when making the Hidden Alarm that might be useful when you make your dance pad? (*A switch can open or close a circuit. Cardboard's flexibility lets it act like a spring.*)
   - Let's brainstorm some designs. How could aluminum foil, cardboard, and plastic wrap be useful in building a dance pad? (*Foil conducts electricity. Cardboard can be used as a base or frame or folded to help make a switch. Plastic wrap is elastic, and its flexibility can be useful for making a switch. Have kids sketch their ideas in their design notebooks.*)

2. **Build, test, and redesign.** (40 minutes) Organize the kids into teams of two and distribute the Challenge Sheets. Have half the teams make pads with buzzers and half make pads with light bulbs. In Challenge 3, you'll need even numbers of each kind of pad. During the activity, help kids debug the following common issues:
   - A buzzer or light doesn't work. *Have kids check for a broken connection or a switch that doesn't open and close properly. Also make sure the buzzer wires are attached to the correct battery terminals.*
   - The pads keep breaking. *Encourage kids to make their pads sturdy enough to withstand all the stomping.*
   - Something needs fixing or adjusting. *Remind kids to provide easy access to the key parts.*

3. **Discuss what happened.** (10 minutes) Have kids show each other their pads and talk about any problems they had and how they solved them. To emphasize the key themes in this challenge—circuits and using materials suitably—ask questions such as:
   - How is your Dance Pad Mania pad similar to your Hidden Alarm? (*It has a circuit; it uses a switch; it converts electrical energy to sound or light; it uses some similar materials.*)
   - What did you do to make sure that your pad would survive being stepped and jumped on?
   - What's an example of how brainstorming helped you come up with a design idea for your dance pad?



Here's one of many ideas for making a dance pad. When you apply a force, plastic wrap stretches. It returns to its original shape once you remove the force. Its springiness and flexibility can be useful in making a switch.

CHALLENGE 2

DANCE PAD MANIA

YOUR CHALLENGE

Build a dance pad that lets you use your feet to sound a buzzer or flash a light.

MATERIALS*

- 1.5-volt AA battery
- AA battery holder (optional)
- Aluminum foil
- Bulb holders for light bulbs (enough for half the group)
- Buzzers (enough for half the group)
- 2 11 x 17-inch sheets of corrugated cardboard (per team)
- Duct tape
- Electrical wire (22-gauge works well)
- Light bulbs that can run on a 1.5-volt AA battery
- Plastic wrap
- Scissors
- Wire strippers

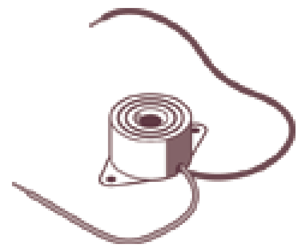
* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

BRAINSTORM AND DESIGN

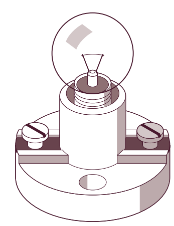
Divide your group into teams of two. Half the teams will make floor pads that flash a light, and the other half will make floor pads that sound a buzzer. When you work as a team, you can often solve design challenges more quickly. For example, you can share knowledge, get new ideas, and brainstorm solutions to problems. You can also learn a lot by looking at how other teams made their pads and seeing how they solved problems.

Your dance pad is basically a super-sized version of the alarm you built in Challenge 1. Like Hidden Alarm, the dance pad has a power source (the battery), materials for conducting electricity (the wires and foil), and something that uses the electricity (the buzzer or light). Yup, that's right, it's an electrical circuit. Before you begin designing, brainstorm answers to the following questions and record your ideas in your design notebook.

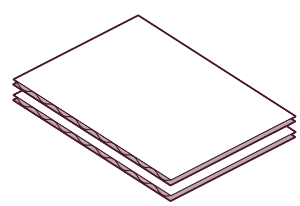
- Will my pad turn on a buzzer or a light?
- How will I build a switch into my pad to turn the buzzer or light on and off?
- How big will my pad be?
- How can I make it sturdy enough to withstand constant stomping?
- Where will I put the battery? Inside the pad? Outside the pad?



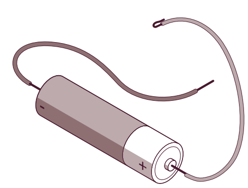
Buzzer



Light bulb and bulb holder



Corrugated cardboard



1.5-volt AA battery

BUILD, TEST, AND REDESIGN

As you build, make sure the circuit works and that it will be able to stand up to some rugged treatment! Once you've built your pad, test it. Step on it several times in a row to turn the buzzer or light on and off. How well did it work? When we made ours, we had to debug some problems. For example, our wires sometimes got loose and our pad stopped working. Also, our switch didn't always work. If things like this happen to you, figure out a way to fix the problem so that your pad works every time.

TAKE IT TO THE NEXT LEVEL

- Make a pad that has both a light and a buzzer.
- Make a pad that uses two batteries, two lights, or two buzzers.

INSIDE THE ENGINEERING

TECHNO GYM

Bust a move! Break it on down and get a good workout at Overtime Fitness™, a revolutionary fitness arcade for teens. Forget what you know about gyms, this is the gym of the future. Get your heart pumping with *In the Groove 2*®, a dance game that works like *Cyber Groove*™, *Dance Dance Revolution*®, *Feet of Fury*™, and *"Pump it Up"*®. Just try keeping up with those moving arrows! How about putting your one-two punch to the test with *MoCap Boxing*®, a virtual game complete with boxing gloves, a 3D virtual opponent, and infrared sensors that track your movements? Or try a game that has you jump, duck, and lunge to avoid virtual dodge balls. You can even hook yourself up to a video game box and become a human joystick to move an on-screen player. Note: The sensors, computers, sound systems, and software that make these games work were all brought to you by engineers. What will those ingenious engineers come up with next!?

Overtime Fitness is a trademark of Overtime Fitness, Inc. *In the Groove* is a registered trademark of Konami Digital Entertainment Co., Ltd. *Cyber Groove* is a trademark of Front Fareast Industrial Corp. *Dance Dance Revolution* is a registered trademark of Konami Digital Entertainment Co., Ltd. *Feet of Fury* is a trademark of Cryptic Allusion Games. *"Pump it Up"* is a registered trademark of Andamiro U.S.A. Corp. *MoCap Boxing* is a registered trademark of Konami Corporation

TAKE IT ONLINE

Want something electrifying? Build a switch and wire up some different kinds of circuits! Download *Turn It On and Off* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

The *Design Squad* cast moves and grooves. They built a floor sensor that used thin foam and metal to make switches that turned sound clips on as they danced.

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

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Design Squad is produced by WGBH Boston. Design and engineering consulting services provided by Continuum.

DANCE OFF

THE CHALLENGE: Start the music, show your moves, and play a game using your dance pad.

Every manufacturer wants its products to perform well. So, manufacturers test their products to make sure they work as expected. In this challenge, kids (1) use their dance pads in a game; and (2) use the design process for two purposes: to assess how a pad's design and assembly affect its reliability, and to debug problems with their dance pads.

1. **Introduce the challenge and the Dance Off game.** (5 minutes) Tell kids today's challenge. Explain that in commercial dance video games, a screen tells the dancer what moves to make. In Dance Off, one team member—the DJ—calls out a sequence of moves for the Dancer to do. The other team members—the Audience—make sure the Dancer does the sequence of moves correctly.

2. **Practice each move.** (5 minutes) Read aloud the four moves listed in Step 1 of the Challenge Sheet. As a group, practice the moves until kids know how to do each one. (*For "Buzz" and "Light," have them imagine that they're standing in front of a light pad and a buzzer pad.)*

3. **Practice a sequence of moves.** (5 minutes) To help kids understand the way the DJ calls out the sequence of moves and the Dancer performs them, do the following practice round:
   - On a board or chart paper, write a sequence of five moves, such as: (1) Yeah (2) Clap (3) Clap (4) Yeah (5) Clap.
   - Read aloud the first move in your sequence, and have the group do it (i.e., say "Yeah").
   - Then, call out Moves 1 and 2 ("Yeah" and "Clap"). Have kids do both moves.
   - Next, call out Moves 1–3 ("Yeah," "Clap," and "Clap"), and have kids do these three moves.
   - Continue by doing Moves 1–4 and then finally do Moves 1–5.

   Point out that in each new sequence, the DJ repeats the moves the Dancer has already done and then adds a new move to the end of the sequence. The challenge, of course, is to do the moves and to remember them as the sequence grows longer!

4. **Review a few details.** (5 minutes) Decide how to rotate roles after each round. Review how points are awarded (see Step 6 on the Challenge Sheet).

5. **Play the game.** (30 minutes) Organize the group into teams (with teams of three to four kids, everyone stays involved), and distribute the Challenge Sheets. During the game, reinforce the idea that a product's reliability is important. Have kids write down any problems that come up during the game. Help kids think through the issues by asking questions such as:
   - Why do you think your pad is malfunctioning?
   - How can you fix the problem so that the game can continue?

6. **Discuss what happened.** (10 minutes) After the game, have kids talk about how they can use what they learned from the game to design a better dance pad. Ask questions such as:
   - Why do you think reliability and durability are important in a product? (*A product should work as expected so people can depend on it and think positively about it.*)
   - What do you think is meant by the term *quality control*? (Quality control *means testing a product thoroughly to make sure it works as expected.*)
   - What kinds of things would help a dance pad stand up to frequent use? (*Sturdy materials, solid electrical connections, reliable switch, and parts taped together well*)
   - What did the game help you understand about designing, making, and testing a product?
   - If you were to redesign this pad, what would you do differently?

CHALLENGE 3

DANCE OFF

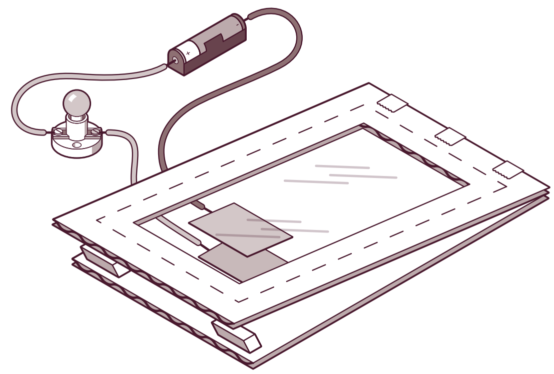
DESIGN SQUAD™

YOUR CHALLENGE

Start the music, show your moves, and play a game using your dance pad.

MATERIALS (PER GROUP)

- 2 pads from the previous challenge: one with a light and one with a buzzer
- Paper
- Pencil
- 3–6 players



HOW TO PLAY

1. **Learn the moves.** Get to know the game's four moves:
   - "*Buzz*" means step on the pad that has a buzzer and make it buzz.
   - "*Light*" means step on the pad that has a light and make it light.
   - "*Clap*" means clap your hands once.
   - "*Yeah*" means say "yeah."
2. **Choose roles.** Decide who will be the Dancer, DJ, and Audience for Round 1.
   - The **DJ** writes down eight moves and calls them out to the Dancer.
   - The **Dancer** uses the pads and his or her hands and voice to do the moves that the DJ calls out.
   - The **Audience** makes sure the Dancer does each action properly and in the correct order.
3. **Write a sequence of moves.** The DJ should write a sequence of eight moves on a piece of paper. For example: 1) Buzz 2) Clap 3) Light 4) Light 5) Yeah 6) Buzz 7) Yeah 8) Clap
4. **Set up.** Get two dance pads—one with a light and one with a buzzer. Set them next to each other. Make sure they work. Have the Dancer stand by the pads.
5. **Play the game.**
   - The DJ reads the first move aloud, and the Dancer does it.
   - Then, the DJ calls out the first move again and adds the second one, and the Dancer must do both moves in the correct order.
   - The game continues, with the DJ reading out Moves 1–3, then Moves 1–4, and so forth until the Dancer does all eight moves in the correct order or misses one.
   - The Audience watches and makes sure the Dancer does the sequence correctly.
   - If a pad breaks during a round, fix it and then keep going. Write down any problems as they happen. Did the tape stop sticking? Did the switch stop working? Did wires come loose? How can you prevent the same thing from happening in the future?
6. **Award points.**
   - *Quality Control Points:* Give each team member ten *Quality Control Points* for each pad that works at the end of the round. (Give points for repaired pads, too, if they last the round.)
   - *Memory Points:* Award the Dancer five *Memory Points* for each move he or she did correctly. (A Dancer can earn 40 points in a round because there are eight moves.)
   - *Audience Points:* Award each Audience member any points the Dancer didn't earn (i.e., 40 minus the points already earned by the Dancer).
7. **Play again.** Continue playing until each group member has had a turn playing each role.

TAKE IT TO THE NEXT LEVEL

- Trade pads with another team.
- Make the sequence ten moves long.
- Invent a fifth kind of move.
- Make a pad where a buzzer buzzes when you step on the right side and a light lights when you step on the left side.

INSIDE THE ENGINEERING

TOYS ARE SERIOUS WORK!

Who wouldn't like to get paid to play with toys? Meet Amanda Bligh, toy engineer for the Hasbro toy company. "I'm a problem solver at heart," says Amanda, "and toy making is a great outlet for engineering. But it's not only the inventing that's great. It's seeing people having fun with the results of my efforts." One of her assignments: the Nerf® Dart Blaster. It took five different designs before she got a dart to go as far as she wanted. Small changes made a big difference. Changing the weight just slightly—by just a quarter of a gram—or reducing the diameter by just two or three millimeters affected how far a dart traveled. By the time she was finished, Amanda got her dart to go 35 feet. Who ever thought that designing toys would take an engineer? Hey, sign me up!

Nerf is a registered trademark of Hasbro, Inc.

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

TAKE IT ONLINE

Want to shine? Make your own illuminated display using light-emitting diodes! Download *Light-emitting Diodes* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

The *Design Squad* cast feels the hip-hop beat. One team started by choosing sound and lighting effects they liked and then figured out where to locate the sensors so they'd be easy to turn on during the dance.

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RUBBER BAND CAR

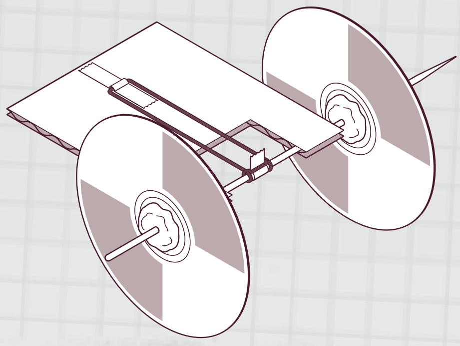
THE CHALLENGE: Build a car that can travel at least four feet using rubber band power.

In this challenge, kids (1) build a car out of a set of parts; (2) get everything to work together efficiently so the car can go at least four feet; and (3) use the design process to debug problems. Having these skills under their belts prepares kids to add a motor and customize their cars in the next two challenges.

1. **Introduce the challenge, brainstorm, and design.** (10 minutes) Before today's meeting begins, make a sample car, following the directions on the Challenge Sheet. Tell kids today's challenge and show them the model you made. Encourage kids to think about how to get the parts to work together by asking:
   - Which parts on this rubber band car can you find on a real car? (*Wheels, axles, power source, and body. Make sure everyone knows what to call the different car parts.*)
   - What's the energy source for this car? (*The rubber band*)
   - Look at the different kinds of rubber bands. How do you think they would affect the way a car will perform? (*Different lengths and widths of rubber bands will wind around the axle differently, store different amounts of energy, and release their energy differently.*)
   - How does the rubber band make the car move? (*As it wraps around the axle, the rubber band stretches. The stretched rubber band pulls on the axle, making it spin.*)
   - The axle is thin but the hole in the CD is big. How can you get the wheels and axle to turn together? (*Put a faucet washer in each CD's hole to fill it up. Then use poster putty to connect the wheels and axle firmly together.*)

2. **Build, test, and redesign.** (35 minutes) Distribute the Challenge Sheets and get kids building. During the activity, help them debug the following common issues:
   - The axle doesn't turn easily. *Make sure it can spin easily in the corrugation. Also check that the catch isn't hitting the cardboard when the axle spins and that the poster putty isn't sticking to the cardboard.*
   - The rubber band wedges itself against the cardboard when it's wound up. *Try winding it more carefully or, as a last resort, widening the notch just a bit.*
   - The wheels wobble or don't point straight. *Make sure that the poster putty is firmly holding the wheels and axle together.*

3. **Discuss what happened.** (15 minutes) Have the kids show each other their cars and talk about how they solved any problems that came up. Emphasize the key themes in this challenge—getting parts to work together, and debugging—by asking:
   - What's the hardest thing about making a car out of lots of different parts?
   - Why was it important for the wheel and axle to spin together as a single unit?
   - In our sign, the "build-test-redesign" part of the design process is shown as a circle. What are some examples of when you had to do something a few times to get your car to run smoothly?
   - What can you learn by looking at other kids' cars? (*Other possible solutions to the problem*)



CHALLENGE 1

RUBBER BAND CAR

YOUR CHALLENGE

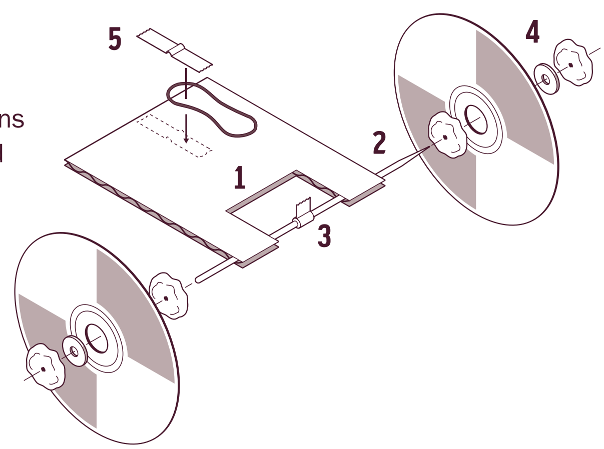
Build a car that goes really fast and really far (at least four feet, that is). Oh, by the way, your power source is a rubber band, and your car can only have two wheels. Start your engines!

MATERIALS (PER CAR)*

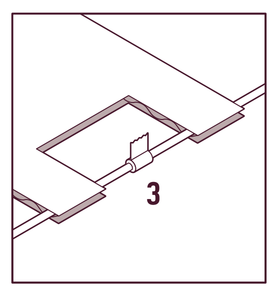
- 2 compact discs (CDs)
- Corrugated cardboard (one piece about 5 ½ inches square)
- 2 faucet washers (Size: ¼ inch Large)
- Poster putty (¼ package—buy the tackiest available)
- Rubber bands of different lengths and widths
- Ruler
- Scissors
- Tape (masking or duct)
- 1 wooden skewer (buy the thinnest available)

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

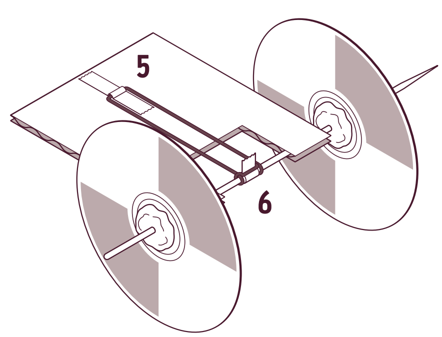
BUILD



1. **Notch the body.** Turn the cardboard so that, as you hold it flat, the corrugations run right and left (i.e., not forward and back). Cut across the corrugations and make a 2-inch-wide and 1 ½-inch-deep notch in the center of the side. Throw away the piece you've cut out.
2. **Make the axle.** Slide the skewer through the cardboard, close to the outer edge. Make sure the axle sticks out the same amount from each side of the body.
3. **Modify the axle.** Find where the skewer goes across the notch. In the middle of this section, wrap a small piece of tape to make a "catch" for the rubber band.



4. **Assemble the wheels.** Slip a washer into the center hole of a CD. Slide the washer and CD onto the axle, leaving lots of room between the wheel and cardboard. Put poster putty on each side of the washer to join the CD, washer, and axle REALLY TIGHTLY TOGETHER. The wheel and axle should now rotate together. Make the second wheel the same way.
5. **Attach a rubber band.** Choose one of the rubber bands. Tape one end to the cardboard at the end opposite the axle.
6. **Power your car.** Wrap the unattached end of the rubber band over the catch. Turn the axle several times. You've given the rubber band ***potential*** (stored) ***energy***. When it unwinds, the axle spins and this potential energy is transformed into ***kinetic*** (motion) ***energy***. The more you wind the rubber band, the more energy can go to your car's wheels—and the farther and faster your car goes.



You've just built a ***prototype***, which is an early version of a product. Prototypes help engineers understand a product's strengths and weaknesses and how it might be improved.

TEST AND REDESIGN

Wind up your car and set it on the floor. What happens when you let it go? When we made ours, we had to debug some things. For example, our axle didn't spin easily, the wheels wobbled, the poster putty stuck to the cardboard, and the rubber band jammed itself against the cardboard. If any of these things happen to you, figure out a way to fix the problem.

TAKE IT TO THE NEXT LEVEL

- Modify the car so it can work on sand or thick carpet.
- Change your car so it can carry a tennis ball.

INSIDE THE ENGINEERING

GLORIOUS GREASE

Greasy fast food may be bad for you, but it can be good for the environment. Take cooking oil. A group of kids converted an old school bus to use waste cooking oil as fuel. They drove it across the country, stopping to fuel up at fast food restaurants. They'd pull up to a restaurant, uncoil a hose, and pump the used grease into the fuel tank. After filtering out the bits of meat, onion ring, or doughnut, they'd drive away—fueled for free. Added bonus: the exhaust smelled like Chinese food, fried chicken, or whatever else got fried in the oil. And Mother Nature was happy—no harmful soot or sulfur dioxide like with regular diesel fuel, and less used cooking oil to clog landfills or pollute waterways. Grease-powered buses motoring around at 60 miles per hour—no wonder they call it *fast* food.

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

TAKE IT ONLINE

Want some zip? Make a self-propelled toy that speeds across the floor! Download *Design, Build, Make It Go!* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

A professional racecar builder challenged the *Design Squad* teams to convert a red wagon and a tricycle into motorized dragsters. The teams raced their creations on a real 1/8-mile drag-race racetrack.

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LEADER NOTES FOR CHALLENGE 2

MOTORIZED CAR

THE CHALLENGE: Make a car that uses a battery-operated motor to travel at least ten feet.

The idea of "if at first you don't succeed, try, try again" is central to the design process and to this challenge, in which kids (1) build a battery-powered car; (2) make a working circuit; and (3) put the design process's try-try-again approach into practice. This work prepares kids to tackle special challenges like obstacle courses or rough terrain in the next challenge. (Note: Save the cars for the next challenge.)

1 **Introduce the challenge, brainstorm, and design.** (10 minutes) Tell kids the challenge for today and begin by asking:

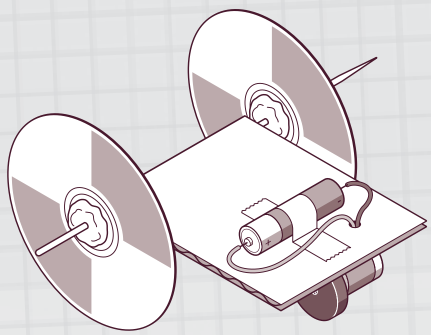
- How will you attach the motor and battery to the car body? (*Tape or poster putty*)
- Where do the motor and battery need to be in order to move the car? (*The battery and wires can be placed anywhere. The motor needs to sit so that the wheel attached to it can touch the ground.*)
- Why do the connections between the battery, motor, and wires need to be really good? (*A gap will interrupt the flow of electrons [i.e., electricity], and the motor won't get the electricity it needs to run. If your kids don't know about circuits, give them time to play with batteries and motors so they can figure out how to wire them before using them in a car. Or have them do the* Hidden Alarm *challenge in the* It's Electric *unit before starting this challenge.*)

2 **Build, test, and redesign.** (35 minutes) Define an area with a smooth floor where kids can test their cars. Distribute the Challenge Sheets. During the activity, help kids debug the following common issues:

- The motor doesn't work. *Check to see if any wires are disconnected.*
- The wheels wobble or don't point straight. *Make sure that the poster putty isn't sticking to the cardboard and that it holds the wheels and axle firmly together.*
- All four wheels don't touch the ground evenly. *One of the wheels is directly connected to the motor, which most kids attach under the body. This makes it sit at a different height from the other wheels. Ask kids if their car really needs to have four wheels. Using three wheels can keep a car stable.* (*See illustration.*)
- The car drives slowly or goes in circles. *Check that there's nothing dragging and that the battery is fresh.*

3 **Discuss what happened.** (15 minutes) Have the kids show each other their cars and talk about any problems they had and how they solved them. Emphasize the key themes in this challenge—circuits, and how the design process relates to redesigning—by asking:

- How are our cars' circuits similar to circuits in real cars? (*They both use batteries and wires to bring electricity to a device that needs it, like a motor.*)
- What can you learn by looking at other cars? (*There are different ways to solve problems. And, even if you use other people's ideas in your design, your car will still be unique.*)
- In our sign, the "build-test-redesign" part of the design process is shown as a circle. What was a time you went back and tried a different approach or idea? How did it help make your car better?



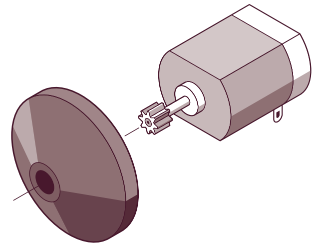
MOTORIZED CAR

YOUR CHALLENGE

Make a car that uses a battery-operated motor to go at least ten feet.

MATERIALS (PER CAR)*

- 1.5-volt AA battery
- AA battery holder (optional)
- Compact discs (CDs)
- Corrugated cardboard (one piece about 5 ½ inches square)
- Electrical wire (22-gauge)
- 8 faucet washers (4, Size: ¼ inch Large; and 4, Size: 1 to 1 ⅛ inch)
- Motor with attached gear that runs on 1.5-volt AA battery
- Poster putty (¼ package—the tackiest available)
- 2 wooden skewers (the thinnest available)
- Scissors
- Tape (masking or duct)
- Wire strippers

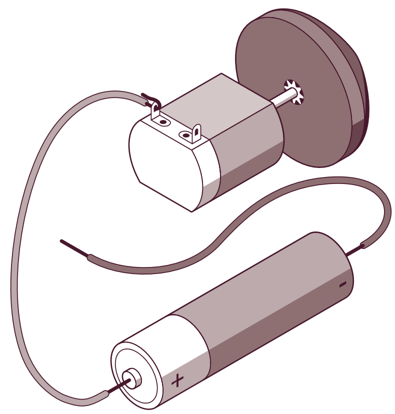


* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

BRAINSTORM AND DESIGN

To begin, look at the materials and consider the following questions:

- The motorized wheel attaches directly to the shaft coming out of the motor. But how will I connect the unmotorized wheels to the car?
- Where do the motor and battery need to be in order to move the car?
- How will I run the wires so they don't interfere with how the car moves?
- How will I make sure the wires stay well connected to the battery and motor?

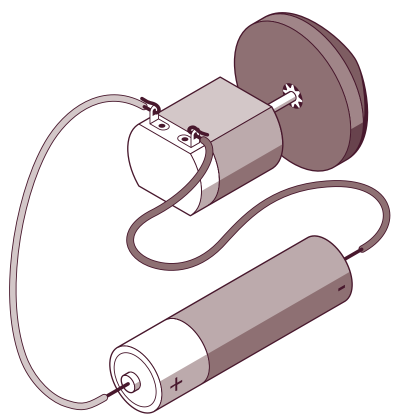


Open circuit

BUILD, TEST, AND REDESIGN

To make your motor work, you'll have to make a ***circuit,*** a pathway for electricity. A circuit has a source of electricity (your battery), something that uses the electricity (the motor), and conductors to carry the electricity (the wires).

Review your materials and think about how you can use them to meet the challenge. Once you've finish building, try out your car in the testing area. When we made ours, we had to debug some things. For example, our motor stopped working, the wheels wobbled, and some parts dragged on the ground. If any of these things happen to you, figure out a way to fix the problem.



Closed circuit

TAKE IT TO THE NEXT LEVEL

- Make your car go faster.
- Make your car more stable for traveling over rough terrain.
- Add a switch to turn your motor on and off.
- Figure out a way to steer your car.

INSIDE THE ENGINEERING

SKYCARS AWAY!

So long, Earth. Looks like soon we'll be flying cars across the sky. At least if engineer Paul Moller has anything to say about it. He's built the Skycar®, a car that can take off and land vertically, hover in the air, go 375 miles per hour, and fly up to 36,000 feet! The Skycar® uses eight computer-controlled engines to get it off the ground and keep the car level while it zips along. Paul is still working out the bugs, like keeping the Skycar® steady and reaching top altitude and speed. There's still a lot to work out, but Paul and his team are working hard to iron out all the bugs. It will take years, but when you get a Skycar® of your own, no parking on the roof, please!

Skycar is a registered trademark of Moller International Corporation

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

TAKE IT ONLINE

Short circuit? Build some circuits and see what happens when they short out! Download *Short Circuits* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

The *Design Squad* cast converted a tricycle into a motorized racecar using battery-powered drills as their power source. The vehicle reached 20 miles per hour.

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CUSTOMIZED CAR

THE CHALLENGE: Each kid chooses a specialized task for his or her car, such as making it go farther than before, having it drive over a rough surface, or adding steering or a switch. Then they change their cars to perform that task.

This is engineering at its best—kids use their imagination and skills to bring an idea to life. Kids see that some changes sound good but are hard to carry out. Some even make the car worse! This challenge caps the unit by giving kids the opportunity to (1) brainstorm lots of interesting ideas; (2) choose one that is doable; and (3) use the design process to debug and to turn an idea into reality.

1. **Introduce the challenge, brainstorm, and design.** (10 minutes) Tell kids the challenge for today and begin by asking:
   - What kinds of things can you change on your car? (*The car's look; wheel size; number of wheels; number of motors or batteries; size of battery, and whether it has a switch*)
   - What are some ways to better control your car? (*Add a switch to turn the motor on and off or develop a way to steer the car.*)
   - What features MUST your car have to work, and which ones would be nice additions? (*A car needs a body, wheels that work, and a power system to move it.*)
   - Name some different ways to make a car's wheels, body, or power system. (*Kids can make wheels from paper plates, yogurt lids, or deli container lids. They can make different-sized car bodies and use both a rubber band and a motor.*)
   - What are some advantages and disadvantages of adding new features to a car? (*Advantages: Improve performance and make it easier to operate. Disadvantages: Add weight, increase the complexity, and require extra materials and construction time*)

2. **Build, test, and redesign.** (35 minutes) Distribute the Challenge Sheets. As they build, help kids think critically about their modifications by asking questions, such as:
   - What was your goal when you made this change?
   - How will you test to see if this change is an improvement over the original design?

3. **Discuss what happened.** (15 minutes) Have the kids show each other their cars and talk about any problems they had and how they solved them. Emphasize the key themes in this challenge—finding a good idea, and how the design process helps turn an idea into reality—by asking:
   - What's your car's new feature and how did you have to change your original design to add it?
   - What ideas did you have to give up because they either were too hard or they made the car worse?
   - Before building, engineers brainstorm. This helps them come up with lots of ideas for solving a problem. The more ideas the better. How did today's brainstorm help you decide which change to make to your car?
   - The design process isn't only for solving problems. It's also a way to turn an idea into reality. When you added the new feature to your car, what were the different steps you had to do to get it to work the way you wanted?

Photo: Lauren Feinberg

CHALLENGE 3

CUSTOMIZED CAR

YOUR CHALLENGE

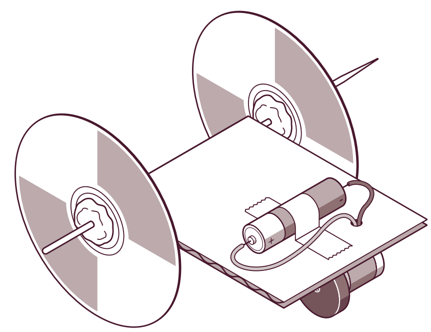
Want a custom car? Well, make it! Today, you're going to change your car to do a specialized task. Let your imagination run wild and change your car any way you want—as long as you can build it!

MATERIALS (PER CAR)*

- Car from Challenge 2
- 1.5-volt AA battery
- AA battery holder (optional)
- Compact discs (CDs)
- Corrugated cardboard in various sizes, cut so the corrugation is visible along the long edge
- Drinking straws (optional)
- Electrical wire (22-gauge)
- 8 faucet washers (4, Size: ¼ inch Large; and 4, Size: 1 to 1 ⅛ inch)
- Motor with attached gear that can run on a 1.5-volt AA battery
- Paper plates (optional)
- Poster putty (¼ package—the tackiest available)
- Rubber bands
- Rulers
- Scissors
- Tape (masking or duct)
- Wire strippers
- Wooden skewers (the thinnest available)

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers. Feel free to add other materials to the list to help spur creative thinking.

BRAINSTORM AND DESIGN

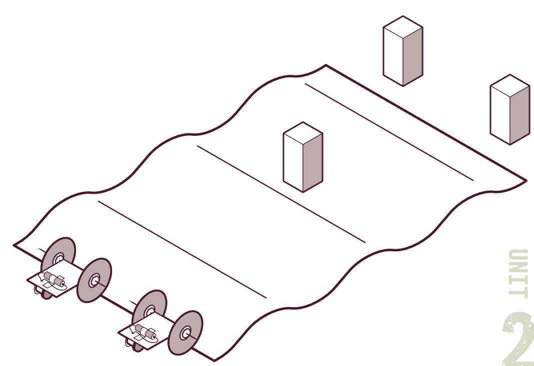


Customize your ride. Are you going for speed? Do you want your car to carry things or push a ball? Do you want to give it a personalized look? How about driving over rough surfaces or going uphill? Maybe make a car that steers or starts and stops with the flick of a switch. Or find ways to reduce friction. Unleash your creativity! Look at the materials and think about the following questions:

- What do I want my car to do?
- What features MUST my car have to work, and which ones would be nice additions?
- What is the best way to add new features to my design?
- Does adding my new feature prevent me from having another feature I want?
- How will all the parts continue to work together after I make changes?

BUILD, TEST, AND REDESIGN

As you build, keep your goal in mind. And when you're done, give your car a name so that people know how it's special. Try out your car in the testing area and see how it performs with its new features. Did it perform as you expected? Identify any problem areas. Make the adjustments necessary to have your car perform the way you want. Then retest.



An obstacle course can put your car to the test.

TAKE IT TO THE NEXT LEVEL

- Add a second new feature to your car.
- Check out other kids' customized cars. If you're inspired by somebody else's idea, add a feature you like.

INSIDE THE ENGINEERING

ZOOM, ZOOM, ZOOM

Talk about a customized ride. Meet racecar engineer Alba Colon. Alba and her team of engineers figure out ways to make NASCAR racecars faster and safer. That means researching and testing things like the car's body shape and the design of its chassis, shocks, tires, and, of course, engine. (Horsepower is Alba's favorite topic!) But the engineers don't have to strap on helmets to do their research. Testing that could once only be carried out on the racetrack can now be done in the lab. They have machines that twist, shake, and jostle cars to simulate the stresses and strains of racing. Other machines test how efficiently cars move through the wind. Alba says that cars are "an extension of your personality. They're also a great engineering challenge—there's always something new to work on. No matter if I'm working on how a car drives, steers, or how fast it goes, engineering gives me the skills I need to tackle any problem."

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

TAKE IT ONLINE

Want to lighten the load? Design a better backpack! Download *Improve a Backpack* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

The *Design Squad* cast built some wonderfully wacky bikes—a back-to-back bike for two people and a side-by-side bike for three. With lights and a horn, the rubber really hit the road with these *Design Squad* choppers.

Major funding for *Design Squad* is provided by the National Science Foundation and the Intel Foundation. Additional funding is provided by Tyco Electronics, National Council of Examiners for Engineering and Surveying, The Harold and Esther Edgerton Family Foundation, Noyce Foundation, Intel Corporation, American Society of Civil Engineers, and the IEEE.

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Design Squad is produced by WGBH Boston. Design and engineering consulting services provided by Continuum.

HIGH RISE

THE CHALLENGE: Build a tower that can support a tennis ball at least 18 inches off the ground while withstanding the wind from a fan.

In this challenge, kids (1) build a sturdy frame out of paper; (2) learn that a solid base helps stabilize a tower; and (3) use the design process to debug problems. This work prepares kids for the next challenge of building a tower with two parts that move in the wind.

1. **Introduce the challenge, brainstorm, and design.** (10 minutes) Tell kids the challenge for today and begin by asking:
   - What is a force? (*A force is a push or a pull.*)
   - Which forces will push on your tower and which will pull on your tower? (*The wind will push on the tower and gravity will pull on it.*)
   - How are tall structures different from low ones? (*A tall structure can tip over if its base is too small or if it is not well anchored to the ground.*)
   - How can we keep a tower from falling over? (*Answers include: Make a wide base; attach string "cables" to steady a tower; make the base heavy; and make a massive, thick tower*)
   - Let's brainstorm some designs. How could you use flexible materials, such as paper and string, to make something tall? (*Kids can stiffen paper by changing its shape [e.g., rolling or folding it] or by reinforcing it [e.g., building up layers]. As with a tent, string can stabilize a tower. Have kids sketch their ideas in their design notebooks.*)

2. **Build, test, and redesign.** (40 minutes) Divide the group into teams of two or three. Distribute the Challenge Sheets and have kids begin building. During the activity, help them debug the following common issues:
   - The tower wobbles or falls over. *Check to see if the base is heavy or wide enough.*
   - The tower buckles with the tennis ball on top. *Stiffen and reinforce the column.*
   - The tennis ball falls off the tower. *Increase the size of the platform under the tennis ball.*

3. **Discuss what happened.** (10 minutes) Have the kids show each other their towers and talk about how they solved any problems that came up. Emphasize key themes in this challenge—how a solid base increases stability, how materials can be used to make a rigid frame, and how debugging can make a better tower—by asking questions such as:
   - What are some things all your tower bases have in common? (*Many towers will have broad, wide bases. They may also be heavy. These designs help prevent a tower from tipping over in the wind.*)
   - Paper is thin and flexible. How did you use it to make a tower? (*Look for examples of where kids stiffened paper by changing its shape or reinforced it by building up layers.*)
   - How was string useful in helping stabilize a tower?
   - What kinds of changes did you make between your first design and your final tower?

Photo: Lauren Feinberg

CHALLENGE 1

HIGH RISE

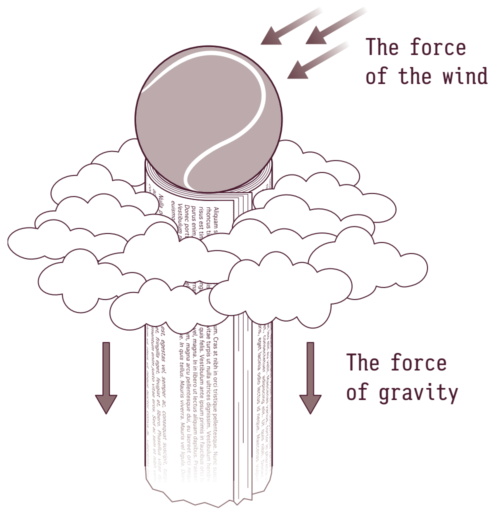
YOUR CHALLENGE

Build a tower that can support a tennis ball at least 18 inches off the ground while withstanding the wind from a fan.

MATERIALS*

- Building surface (tray, cardboard, or piece of wood)
- Electric fan
- Paper (copier paper and/or newspaper)
- Straws
- String
- Tape (masking or duct)
- Tennis ball
- Wooden skewers or Popsicle sticks

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

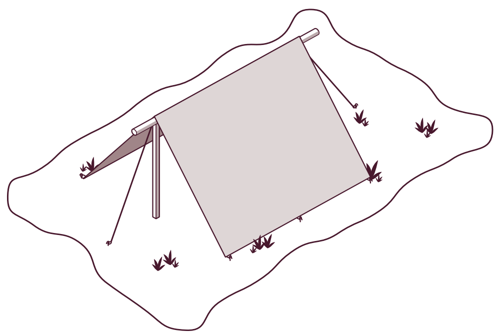


BRAINSTORM AND DESIGN

Divide into teams of two or three. Before you begin designing, brainstorm answers to the following questions. Record and sketch your ideas in your design notebook.

- How can we use our materials to make a tower that's at least 18 inches tall?
- How can we use flexible materials, such as paper and string, to make a tower that is strong enough to hold up a tennis ball?
- How can we keep our tower from tipping over?
- How will we design our tower to resist the push of the wind and the pull of gravity?

As you brainstorm designs for your tower, think about other structures and how they stand up. For example, a tent combines flexible and rigid materials to make a frame and covering that can stand on its own.



A tent combines flexible and rigid materials to make a structure that can stand on its own.

BUILD, TEST, AND REDESIGN

Once you've got a tower to test, put it one foot away from the fan. (If your tower is hard to move, bring the fan over to the tower.) See how your tower responds when you turn the fan speed on low. When we made ours, we had to debug some problems. For example, our tower tipped over, our tennis ball kept falling off, and the weight of the tennis ball bent our tower. If any of these things happen to you, figure out a way to fix the problem so that your tower works as expected.

TAKE IT TO THE NEXT LEVEL

- Strengthen your tower so it can support a tennis ball when the fan speed is set to high.
- Build a tower that can support a baseball, softball, or soccer ball instead of a tennis ball.
- Make a tower that can support a tennis ball that's 36 inches off the ground.

INSIDE THE ENGINEERING

WIPE OUT

When you're schussing down the slope at 80 miles per hour, who's got time to think about whether your snowboard will hold together? That's where Chris Fidler comes in. He's an engineer at Burton Snowboards®. Chris thinks a lot about snowboards so you don't have to. Snowboarding since he was a kid, Chris now works with designers to build what he thinks makes the best snowboard. To make a board, Chris presses thin layers of fiberglass, metal, and plastic together—sort of like a club sandwich. Each material's thickness and shape (e.g., corrugation, strips, tubes, and mesh) affects the board's strength and flexibility. Chris then subjects his boards to a series of tough tests. Robotic instruments twist, bend, and pound the boards to see how much force they can take before breaking—something you definitely *don't* want to find out when you're catching air on a halfpipe!

Burton Snowboards is a registered trademark of The Burton Corporation

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

TAKE IT ONLINE

Want to avoid a mess? Select the best materials for different drink containers! Download *Materials Choice* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

The *Design Squad* cast tapped their "inner artists" as they designed and built wind-powered sculptures from recycled materials. One sculpture—The Aqu-AIR-ium—had a heavy steel base and sheet metal fins so the "bowl" full of fish could rotate in the wind.

Major funding for *Design Squad* is provided by the National Science Foundation and the Intel Foundation. Additional funding is provided by Tyco Electronics, National Council of Examiners for Engineering and Surveying, The Harold and Esther Edgerton Family Foundation, Noyce Foundation, Intel Corporation, American Society of Civil Engineers, and the IEEE.

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KINETIC SCULPTURE

THE CHALLENGE: Build a tower that's at least 12 inches high with two or more parts that move in the wind.

In general, a tower's moving parts can spin (like a pinwheel), sway (like a branch or swing), or flap (like a flag). In this challenge, kids (1) design a system that allows at least two parts to move in the wind; (2) build a sturdy structure to support the moving parts; and (3) create a base that lets the tower stay up even when the parts shift their positions.

1 **Introduce the challenge, brainstorm, and design.** (10 minutes) Tell kids the challenge and begin by asking:

- What are some different ways that wind can move something? (*Parts can either move in circles—spin, twirl, or twist, or they can move back and forth—rock, sway, flap, or tip.*)
- What do you need to consider when designing a tower that has moving parts? (*The tower needs to be stable enough to withstand the wind and to stay upright each time the parts move.*)
- In the last challenge, what did you learn about towers that might be helpful in this challenge? (*A wide or heavy base helps stabilize a tower. Paper can be stiffened by changing its shape or by layering or reinforcing it.*)
- What kinds of materials would be good for the moveable parts? (*Materials that can catch the wind while not adding too much weight to the top of the tower*)
- Let's brainstorm some designs. How might you use the materials to make something that's both tall but has parts that move? (*Encourage kids to sketch their ideas in their design notebooks.*)

2 **Build, test, and redesign.** (40 minutes) The wide selection of items in the materials list is intended to spark creative solutions to the challenge. You should also feel free to add other items. Distribute the Challenge Sheets and have kids begin building. During the activity, help them debug the following common issues:

- The tower falls over in the wind. *Widen or add weight to the base. Also, check how the weight is distributed—if most of it is near the bottom, the tower will stay up better.*
- The parts don't move as expected. *For spinning parts, make sure that the parts turn without catching and that kids have centered the axle and minimized friction. For swaying parts, make sure they're wide enough to catch the wind and are attached in a way that lets them move back and forth easily.*

3 **Discuss what happened.** (10 minutes) Have the kids show each other their sculptures and talk about how they solved any problems that came up. Emphasize key themes in this challenge—a stable base, a tower supported by a sturdy structure, and moving parts—by asking questions such as:

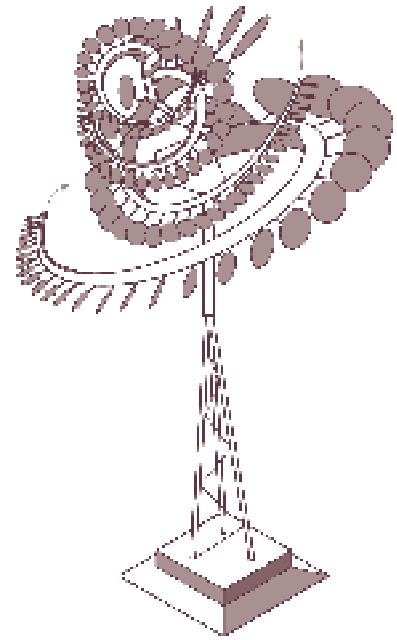
- What do you think is the best feature of your design? Why?
- How is the tower you built in this challenge similar to and different from the one you built last time? (*They both have a rigid frame or column and a base that provides good support.*)
- What kind of moving part—spinning or swaying—is harder to build? Why? (*Generally, friction issues and getting the axle system to work smoothly make spinning parts harder to build.*)
- How much would you have to change your design to add a third moving part?

CHALLENGE 2

KINETIC SCULPTURE

YOUR CHALLENGE

Build a tower that's at least 12 inches high with two or more parts that move in the wind. That's what makes it *kinetic*—it moves.



The Cyclone

MATERIALS*

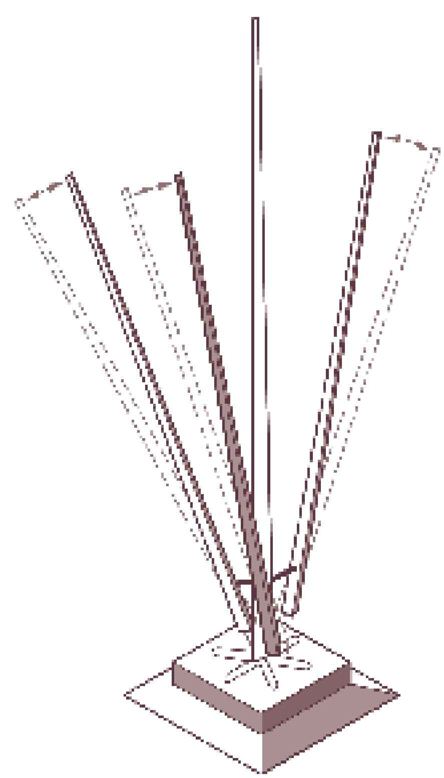
- Aluminum foil
- Cardboard (corrugated or chipboard)
- Clay
- Electric Fan
- Foil baking dishes (disposable pot-pie-sized)
- Metal washers (various sizes)
- Paper (copier or newspaper)
- Paper cups (various sizes)
- Ping-Pong balls
- Plastic grocery bags
- Poster putty
- Rulers
- Scissors
- String
- Strips of colored paper or fabric
- Tape (duct or masking)
- Wooden skewers or dowels

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

BRAINSTORM AND DESIGN

Looking for inspiration? Get your creative juices flowing by checking out the kinetic sculpture illustrations. Don't worry, it's not cheating! Being inspired by other people's work and putting things you like together in new ways is a great way to come up with a unique creation of your own. Before you begin designing, brainstorm answers to the following questions. Record and sketch your ideas in your design notebook.

- How will my parts move? Spin? Sway? Flap? A combination?
- What kinds of materials would be good to use for the moveable parts?
- How will I attach the parts to the base or tower so they can move in the wind?
- How could having moving parts at the top of a tower affect how I design my tower?



Tall Grasses

BUILD, TEST, AND REDESIGN

Sculptors typically name their creations, which can add meaning to them. As you build your sculpture, think up a name for it. Try for a name that's descriptive, funny, or mysterious. Test your sculpture by setting it in front of the fan. Do the parts move as you expected? When we made ours, we had to debug some problems. For example, the wind knocked our sculpture over. Also, our parts didn't always move the way we wanted, especially the parts that turned. If things like this happen to you, figure out a way to fix the problem so that your sculpture works every time.

TAKE IT TO THE NEXT LEVEL

- Add another moving part.
- Make your sculpture twice as tall.
- Build a sculpture that could work in either more or less wind.

INSIDE THE ENGINEERING

TOWER POWER

What would make a tower stand up in typhoon-strength winds (74 miles per hour or greater)? That's something the engineers who built one of the tallest buildings in the world—the Taipei 101 Tower of Taiwan (1,670 feet tall)—were worried about. Very worried! Typhoons regularly slam into Taiwan. To keep the building from being blown over, engineers made the skyscraper much wider at the bottom than at the top. They also used special materials, including strong, flexible steel, to make the building sturdy enough to withstand those typhoons. So next time you're visiting the top of the Taipei 101 Tower during a typhoon, you don't have anything to worry about. Right?

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

TAKE IT ONLINE

Like building things that move? Make a unique mechanical toy! Download *Gears, Cranks, Crankshafts, and Belts* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

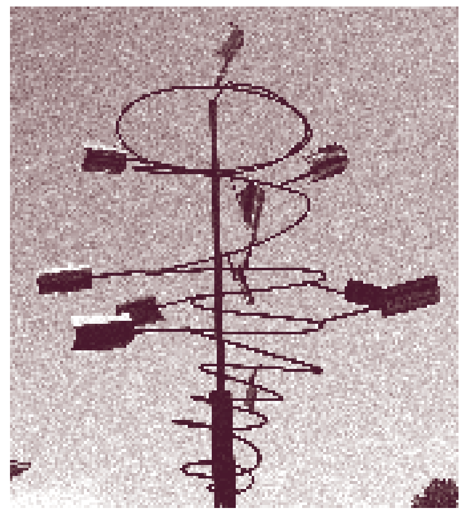


Photo: Mika Tomczak

The *Design Squad* cast welded their kinetic sculpture out of heavy scrap metal. They set their "Urban Tornado" atop a steel pole and used metal fins to catch the wind and spin the sculpture.

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KICKING MACHINE

THE CHALLENGE: Build a machine that kicks a Ping-Pong ball into a cup lying on its side 12 inches away. Use either (1) a pendulum, (2) a rubber band, or (3) a combination of the two to do this.

We use machines to move things for us all the time, and they use energy to do it. This energy can be stored (i.e., potential energy), for instance, as fuel, weights, or springs and then released at a later time (i.e., kinetic energy). In this challenge, kids (1) build a machine that uses energy stored in a pendulum or a rubber band to set a ball in motion; and (2) test the accuracy of their machines by shooting a Ping-Pong ball into a cup.

1 **Introduce the challenge, brainstorm, and design.** (10 minutes) Tell kids the challenge for today and begin by asking:

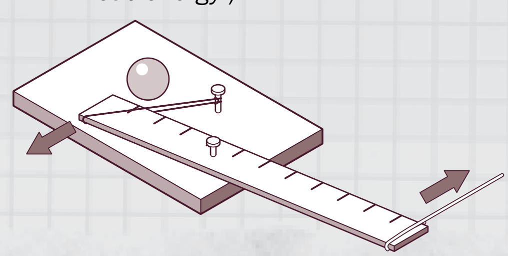
- What are examples of machines that people use to set balls in motion? (*Pinball machines; ball machines used by tennis, soccer, and baseball teams in their practices*)
- How can you use gravity to get a ball moving? How can a rubber band get a ball moving? (*Gravity will move a ball if you drop it, roll it down a ramp, or hit it with the end of a swinging pendulum. A rubber band will move a ball if you pull it back and then release it so it hits the ball.*)
- How can you make a pendulum or rubber band store up energy? (*Lifting the pendulum or stretching the rubber band stores energy that can later be released.*)
- Let's brainstorm some designs. What kinds of devices could use a pendulum or rubber band to set a ball in motion? (*A pendulum device could be a golf ball taped to a string or piece of cardboard hanging from a frame. To use it, kids would pull back the pendulum, let go, and let it knock into a ball placed in its path. A rubber band device could have a rubber band stretched between two posts. Have kids decide what kind of kicking machine they will build and sketch their ideas in their design notebooks.*)

2 **Build, test, and redesign.** (40 minutes) Have kids decide whether they will build a pendulum- or rubber band-based launching system. Distribute the Challenge Sheets and have kids begin building. During the activity, help them debug the following common issues:

- The ball is hard to get into the cup. *Make sure the machine sends the ball in a predictable direction. Try different release points for the pendulum or rubber band. Test on a smooth surface. Check whether the ball bumps into part of the machine on its way out.*
- The stretched rubber band bends the frame. *Use stronger materials, or make the frame stronger by reinforcing it.*
- The rubber band won't stay hooked once it's been pulled back. *Use a paper clip or piece of cardboard to make a solid anchor. Or, tie a piece of string to the middle of the rubber band and use it to pull back the rubber band. Then secure the string.*

3 **Discuss what happened.** (10 minutes) Have the kids show each other their kicking machines and talk about how they solved any problems that came up. Emphasize key themes in this challenge—using stored energy and building workable machines—by asking questions such as:

- What are some advantages of a pendulum-based machine? A rubber band-based machine?
- How did you determine the right amount of energy to store up before making your shot?
- How did the two kinds of machines compare as to how well they got the ball into the cup?
- What are examples of potential and kinetic energy in your kicking machine? (*The lifted pendulum and stretched rubber band are examples of potential energy. The moving ball, swinging pendulum, and rubber band just after it was released are examples of kinetic energy.*)



CHALLENGE 1

KICKING MACHINE

DESIGN SQUAD™

YOUR CHALLENGE

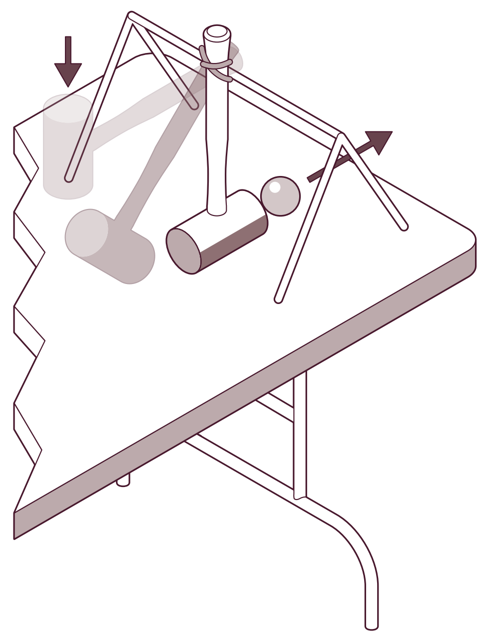
Build a machine that kicks a Ping-Pong ball into a cup lying on its side 12 inches away. Use either (1) a pendulum, (2) a rubber band, or (3) a combination of the two to do this.

MATERIALS*

- Balls (Ping-Pong and golf)
- Corrugated cardboard
- Paper clips
- Paper cups
- Popsicle sticks
- Rubber bands
- Ruler
- Scissors
- String
- Tape (masking or duct)
- Thin metal wire (optional)
- Wooden skewers

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

BRAINSTORM AND DESIGN



Before you begin designing your machine, brainstorm answers to the following questions. Record and sketch your ideas in your design notebook.

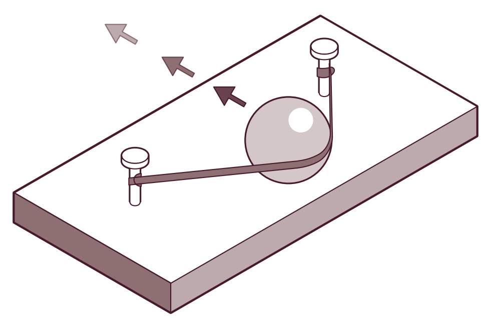
- Will my machine use a pendulum or rubber band (or a combination) to send a ball into the cup?
- How will I stop the machine from launching the ball before I'm ready to release it?
- How will the machine be triggered when I'm ready to launch the ball?
- How will I make sure the pendulum or rubber band launches the ball straight enough and with the right amount of force so it goes into the cup?

Think about how to create different release points for the pendulum or rubber band so you have more control over a launched ball. Also consider how to determine the right amount of energy to store up before making your shot.

BUILD, TEST, AND REDESIGN

When you lift a pendulum or stretch a rubber band, you increase its potential energy. ***Potential energy*** is energy that is stored. When you release the pendulum or rubber band, its potential energy is turned into ***kinetic energy***, the energy of motion. Many machines have this in common—they turn potential energy (e.g., fuel, electricity, muscle power, springs, or weights) into kinetic energy that can be used to do a task (in this case, launch a ball).

Once you've built your machine, test it. Lay a cup on its side 12 inches away and see if you can get the ball in. When we made our machine, we had to debug some problems. For example, the ball bumped into parts of our machine and went in unexpected directions, and the stretched rubber band bent our frame. It was also hard to get the pendulum and rubber band to stay pulled back. If things like this happen to you, figure out a way to fix the problem so that your machine works every time.



When you lift a pendulum or stretch a rubber band, you increase its potential energy.

TAKE IT TO THE NEXT LEVEL

- Move the cup so it's 24 inches from your kicking machine.
- Build a ramp and see if you can shoot the ball up and over the ramp.
- Build a machine that can launch two balls at once or that can launch balls at different speeds.

INSIDE THE ENGINEERING

SWEET DELIVERY

Building machines that make tasty—and sometimes far-out—ice cream flavors is just the kind of challenge Pete Gosselin loves. He's head engineer for Ben and Jerry's® ice cream. Pete's the guy who designs the machines that make different flavors and mix the right amounts of candy, filling, or swirl into each container. And you thought getting a ball into a cup was a challenge! Some days, it's, "We want every container to have half a pint of cherry ice cream with cherries and fudge flakes and half a pint of chocolate ice cream with fudge brownies. Now on the brownie side, make sure there are at least three but no more than four brownie bites. Oh and by the way, these babies need to roll off the production line at 200 pints a minute." To make some flavors, Pete tinkers with the factory's existing machines. For others, he has to design special machines. His biggest challenge: to design a machine that makes a flavor with a core of fudge and caramel wedged between chocolate and caramel ice cream. The way Pete sees it, "The world is full of problems and possibilities. And technology has a huge influence on making our lives better, whether the challenge is addressing global warming or making delicious food."

Ben and Jerry's is a registered trademark of Ben & Jerry's Homemade Holdings, Inc.

TAKE IT ONLINE

Want to make life easier? See how simple machines bring mechanical advantage to the rescue! Download *Not So Simple Machines* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

The *Design Squad* cast made a kicking machine for a professional soccer player. This soccer-ball launcher uses electric drills to spin wheelbarrow wheels to send soccer balls flying.

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

Major funding for *Design Squad* is provided by the National Science Foundation and the Intel Foundation. Additional funding is provided by Tyco Electronics, National Council of Examiners for Engineering and Surveying, The Harold and Esther Edgerton Family Foundation, Noyce Foundation, Intel Corporation, American Society of Civil Engineers, and the IEEE.

This *Design Squad* material is based upon work supported by the National Science Foundation under Grant No. ESI-0515526. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Design Squad is produced by WGBH Boston. Design and engineering consulting services provided by Continuum.

LEADER NOTES FOR CHALLENGE 2

EXTREME KICKING MACHINE

THE CHALLENGE: Modify your kicking machine. Have it either release the pendulum or rubber band when you're standing three feet away, or have it automatically feed balls into the kicking machine, one after another.

We increase the usefulness of machines in many ways—we automate them, add features, and change their size. In this challenge, kids (1) design either a remote release or a delivery feature for their kicking machine; (2) integrate the new feature into the existing structure; and (3) use the design process to make sure the modified kicking machine works the way they want it to.

1 **Introduce the challenge, brainstorm, and design.** (10 minutes) Tell kids the challenge for today and begin by asking:

- What are examples of devices or toys that you can operate without touching them directly? (*Radio-controlled toys, kites, fishing rod, garbage can with lid that lifts when you step on the footpad, gripper for grabbing things on high shelves, plumber's snake*)
- What are examples of devices or toys that can hold lots of balls or other items and release them one ball (or a little bit) at a time? (*Pinball machines, tennis-ball and pitching machines, gumball machines, bulk food dispensers, and PEZ® dispensers*)
- Let's brainstorm some designs. What could you add to your machine that would let you launch a ball when you're standing three feet away? What could you add that would let you automatically feed balls into your machine? (*To release the pendulum or rubber band remotely, kids could make a trigger from string and paper clips, wooden skewers, or Popsicle sticks. To feed balls into a machine one after another, kids could build a chute that holds balls using a set of removable gates, a box with a door that opens and lets out one ball at a time, or a column of stacked balls that lets a ball drop into position. Have kids decide whether they will build a remote release or an automatic feeder for their kicking machines, and have them sketch their ideas in their design notebooks.*)

2 **Build, test, and redesign.** (40 minutes) Distribute the Challenge Sheets and have kids begin building. During the activity, help them debug the following common issues:

- The balls don't automatically feed into the machine. *Check that the balls can roll or fall freely. Increase the angle of the chute. If balls keep rolling off the launching pad, make a better "pocket" to hold them.*
- The remote release doesn't let go easily. *Reduce friction as much as possible. To help the trigger release, reduce the amount of force on it, or make it bigger to increase the leverage.*

3 **Discuss what happened.** (10 minutes) Have the kids show each other their modified kicking machines and talk about how they solved any problems that came up. Emphasize key themes in this challenge—designing and integrating a new feature—by asking questions such as:

- Today's kicking machine has two features. Is a machine with two features a little more or a lot more complex than a machine with a single feature? (*Complexity usually increases as the number of features increases.*)
- Why can adding a new feature be challenging? *(Often, you have to undo something that's working well in order to add a new feature.)*
- What would you do differently if you had more time?

Photo: Margot Sigur

EXTREME KICKING MACHINE

YOUR CHALLENGE

Modify your kicking machine. Have it either release the pendulum or rubber band when you're standing three feet away, or have it automatically feed balls into the kicking machine, one after another.

MATERIALS*

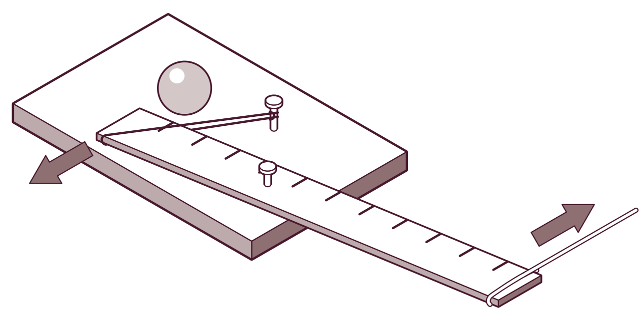
- Kicking machine from previous challenge
- Aluminum foil
- Corrugated cardboard
- Paper clips
- Paper cups, plates, and bowls
- Ping-Pong balls
- Popsicle sticks
- Rubber bands
- Ruler
- Scissors
- String
- Tape (masking or duct)
- Thin metal wire (optional)
- Wooden skewers

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

BRAINSTORM AND DESIGN

Before you begin designing, brainstorm answers to the following questions. Record and sketch your ideas in your design notebook.

- Will I add a feature that lets me launch a ball remotely or one that lets me automatically feed balls into my kicking machine?
- For the remote-release feature, how will I release the pendulum or rubber band without touching it directly with my hand?
- For the automatic feeder, how will I get balls into position on the kicking machine's launch pad?
- What parts of my existing kicking machine do I have to change in order to add my new feature?



BUILD, TEST, AND REDESIGN

As you add your new feature, make sure your kicking machine can still do its original task—getting a ball into a cup placed 12 inches away. When we made our machine, we had to debug some problems. For example, with our automatic feeder, the balls didn't fall perfectly into place. We found that our remote release didn't let go easily. If things like this happen to you, figure out a way to fix the problem so that your machine works every time.

EXTREME KICKING MACHINE

TAKE IT TO THE NEXT LEVEL

- Design a remote system that allows you to pull back the pendulum or rubber band and then release it.
- Design an automatic feeder that allows you to launch three balls in ten seconds.

INSIDE THE ENGINEERING

ROBOTS TO THE RESCUE!

Meet BEAR. Cute and cuddly, he's not, but one day he might save you from a burning building. At six feet and 200 pounds, BEAR (Battlefield Extraction-Assist Robot™) is a silver robot with a bear-shaped head, big purple eyes, and paddle-like paws. It sports night vision and can climb stairs and travel 10 miles per hour. Designed by engineer Debbie Theobald, BEAR is built to go into dangerous places, like mines or battlefields, and find and carry up to 400 pounds-worth of people to safety. It's taken Debbie and her team of five engineers six years to develop BEAR. As Debbie says, "Why put people's lives at stake when you can send in a robot?"

Battlefield Extraction-Assist Robot is a trademark of Vecna Technologies, Inc.

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

TAKE IT ONLINE

How inventive are you? Design a new paper clip that can multitask and looks cool at the same time! Download *Build a Better Paper Clip* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

Photo: Mika Tomczak

The *Design Squad* cast designed kicking machines to automatically feed a stream of soccer balls to a player at different angles and heights.

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CONTENT STANDARDS

The challenges in this guide address the following ITEA National Study of Technology Content Standards and the Massachusetts Curriculum Frameworks' Science and Technology/Engineering Standards.

	Massachusetts Curriculum Frameworks Science and Technology/Engineering Standards																	ITEA National Study of Technology Content Standards												
	Grades 3–5											Grades 6–8						Grades K–12												
	Materials and Tools			Engineering Design			Physical Science					Materials, Tools, and Machines	Engineering Design				Physical Science	The Nature of Technology		Technology and Society	Design			Abilities for a Technological World		The Designed World	
Challenge	1.1	1.2	1.3	2.1	2.2	2.3	1	4	5	6	7	1.1	2.1	2.2	2.3	2.4	1.3	1	2	6	8	9	10	11	12	16	20
Hidden Alarm	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	
Dance Pad Mania	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	
Dance Off	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	
Rubber Band Car	●	●	●		●	●	●	●	●			●	●	●	●	●	●	●	●		●	●	●	●	●	●	
Motorized Car	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●		●	●	●	●	●	●	
Customized Car	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●		●	●	●	●	●	●	
High Rise	●	●		●	●	●	●					●	●	●	●	●		●	●		●	●	●	●	●	●	●
Kinetic Sculpture	●	●	●		●	●	●	●	●			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Kicking Machine	●	●	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Extreme Kicking Machine	●	●	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

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WELCOME TO THE WORLD OF DESIGN SQUAD

***Design Squad* gets kids and teens thinking like engineers and shows them that engineering is fun, creative, exciting, and something they can do themselves.**

Photo: Mika Tomczak

The Television Series

Competition plus engineering plus fun! Two teams of high school kids use their problem-solving skills to design, construct, and test engineering projects.

The Web Site

Get cast information, descriptions of the show's engineering challenges, games, an e-zine, and video clips. Try it out at pbskidsgo.org/designsquad/engineers.

The Outreach Campaign

Through events, trainings, and activity guides, it's easy to deliver activities to places where kids and teens can be found: in afterschool programs, schools, museums, and even the local mall. Become a part of it!

Photo: Laruen Feinberg

The Outreach Partners

***Design Squad* is building a community committed to fostering a positive image of engineering. For a current list of partners and to join this growing community, visit the *Design Squad* Web site at pbskidsgo.org/designsquad/engineers.**

PBS Watch *Design Squad* on PBS (check local listings)

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