LEADER NOTES FOR CHALLENGE 1

KICKING MACHINE

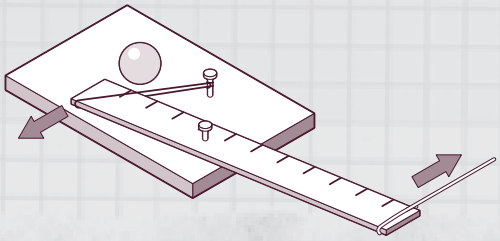
THE CHALLENGE: Build a machine that kicks a Ping-Pong ball into a cup lying on its side 12 inches away. Use either (1) a pendulum, (2) a rubber band, or (3) a combination of the two to do this.

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

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

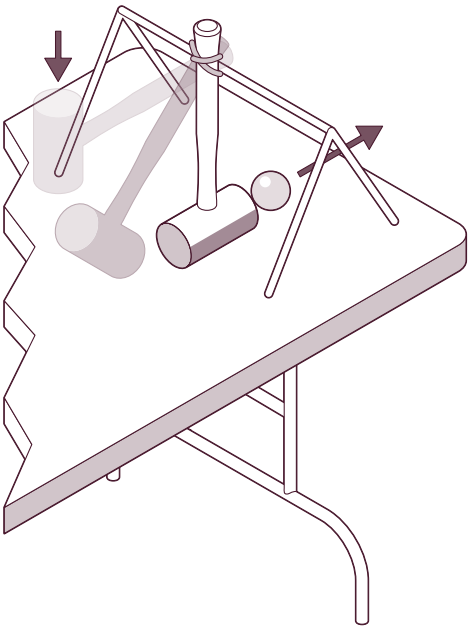
* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

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?

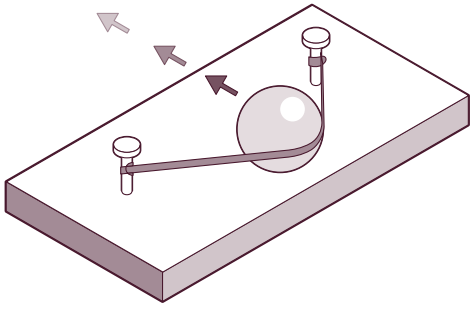
Think about how to create different release points for the pendulum or rubber band so you have more control over a launched ball. Also consider how to determine the right amount of energy to store up before making your shot.



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.

DESIGN SQUAD

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.

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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

CHALLENGE 2

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*

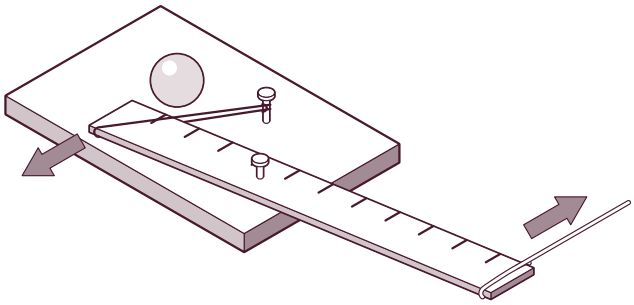
- Kicking machine from previous challenge
- Aluminum foil
- Corrugated cardboard
- Paper clips
- Paper cups, plates, and bowls
- Ping-Pong balls
- Popsicle sticks
- Rubber bands
- Ruler
- Scissors
- String
- Tape (masking or duct)
- Thin metal wire (optional)
- Wooden skewers

* 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.

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.**

PBS

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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