ELECTRIC GAMEBOX CHALLENGE

First, students use copier-paper box tops (with their convenient built-in sides) for their game boards.

Then, students design pressure-sensitive targets that buzz when hit by a Ping Pong ball.

The Challenge: Invent a pinball-like game where your kick stick hits a Ping Pong ball into a target that buzzes.

Preparation

- ☐ Copy the *Electric Gamebox* handout (one per student).
- ☐ Visit pbs.org/designsquad and download the following video clips from the "Teacher's Guide" page: ***Design Process: Teamwork*** (1 minute) and ***Switches*** (1 minute). Be prepared to project them.
- ☐ Gather these materials (per student). See page 44 for suppliers.
  - kick stick from the previous session
  - battery, either 9 V and connector or AA and holder (see step 4)
  - buzzer
  - paper clips
  - scissors
  - aluminum foil
  - wire strippers
  - shallow box (e.g., copier-paper box top, lettuce box, berry box, etc.)
  - duct tape
  - paper cup (4 oz.)
  - Ping Pong ball
  - hook-up wire (e.g., 22-gauge, stranded)

1 Introduce the challenge (5 minutes)

Point out that, in the *Design Squad* TV challenge, the client is a soccer player whose job is to kick a soccer ball into a goal. Tell students that today's challenge is similar—to invent a game where their kick sticks hit a Ping Pong ball into a target that buzzes when the ball hits it. The target could be a cup, a hole, or a goal—the choice is theirs. Ask:

- What are some ball-and-target games you like? *(Pinball, bowling, mini-golf, billiards, air hockey, foosball, hockey, soccer, basketball, etc.)*
- What kinds of things use pressure-activated switches? *(Automatic door; seat belt sensor; vending machine; elevator button; door bell; computer keyboard; etc.)*

2 Brainstorm (10 minutes)

Brainstorm the circuit

- Hold up a buzzer and ask students how they would make it buzz. *(Attach it to a battery.)*
- Connect the leads of the battery holder and buzzer. Ask: What do you notice when you connect the different-colored wires from the battery to the buzzer? *(Let students figure out that the buzzer only works when the leads are connected red-to-red and black-to-black. This is because, to work, a buzzer uses an internal* ***electromagnet****. If the current runs the wrong way, the electromagnet doesn't work and the buzzer can't buzz.)*
- How can you rig up a switch so the buzzer buzzes when the ball hits a target mounted on a wall? *(The target could be a sheet of foil hanging down, which gets pushed back onto a contact [e.g., wires or paper clips] when the ball hits the foil.)*
- How can you rig up a switch so the buzzer buzzes when the ball falls into a cup? *(The ball could drop into a cup and land on some foil. This pushes the foil down onto contacts at the bottom of the cup, closing the circuit. Students could also wrap a ball in foil. When the ball falls into the cup, the foil would bridge the gap between two contacts.)*

- Show the ***Switches*** animation. The switches in the animation run circuits connected to components like computers rather than to buzzers, as in *Electric Gamebox*. Still, students will see how switches work and that there are different ways to open and close a circuit.

Brainstorm the design process

- Show the ***Design Process: Teamwork*** video. Discuss the Green Team's comments and have students brainstorm strategies that could enhance teamwork, such as listening and adjusting one's style to help things work smoothly.

3 Summarize the problem to solve (5 minutes)

- Break the larger challenge into its sub-challenges. Ask: What are some of the things you'll need to figure out as you make your game? *(What kind of game board to make; where the target will go; how to add a switch and a buzzer to the target; and how to build a circuit)*
- To promote creative thinking and foster a sense of ownership, have students pair up and brainstorm their own ways of turning the materials into a game with a buzzing target. Distribute the handout, and have them sketch their ideas.

4 Build, test, and redesign (30 minutes)

Here are some strategies for dealing with issues that may come up during building:

- **Cutting cardboard:** Since students will be cutting corrugated cardboard, provide scissors that are up to the task. If necessary, show students how to cut thick materials without hurting themselves. Point out that it's easier to cut a square hole than a round hole, and that, since a cup is flexible, students can easily push it into a square hole.
- **Planning ahead:** A cup with a battery and/or buzzer attached won't fit through the hole. Push the cup through the hole, and *then* have students attach the wires, paper clips, battery, and buzzer.
- **The buzzer doesn't buzz:** Weed out defective buzzers by having students check that their buzzers work before they start building. (Make sure their leads are red-to-red and black-to-black.) Also make sure the circuit works by using your fingers to close it manually. Finally, buzzers work best when supplied with lots of electricity. Check that the batteries are fresh. Students can also connect two AA batteries in series, doubling the voltage. Finally, consider using 9-volt batteries with battery caps. With 9 volts, the buzzers will roar to life the instant the switch closes, a real advantage considering that a Ping Pong ball may only close a switch for a very brief moment.
- **Switches work inconsistently:** A switch that has small contacts can be hard to close. Have students attach a paper clip or large piece of foil to the ends of their wires. The larger contacts will make it easier to close the circuit. Also, some switches use a sheet of foil that hangs down. When the ball hits the foil, the sheet swings back, onto a wire. This closes the circuit, and the buzzer buzzes. If there's no sound, be sure that students have positioned the contact wire at the correct height—about where the ball hits the target.

Next, students test their kick sticks and gameboxes, making adjustments as needed.

Finally, in *Making It Real*, students discuss the science and engineering behind their designs and describe how they are thinking and working like engineers.