KICK STICK CHALLENGE

First, students brainstorm and sketch ideas for their kick stick's circuits, switches, and kicking arms.

Then, students apply what they know about circuits, conductors, and switches and learn how to use wire strippers and tear duct tape.

The Challenge: Build a handheld "kick stick" that uses a motor-driven, spinning arm to kick a Ping Pong ball across the floor.

Preparation

- ☐ Copy the *Kick Stick* handout (one per student).
- ☐ Visit pbs.org/designsquad and download the following video clips from the "Teacher's Guide" page: ***Just for Kicks Challenge*** (1 minute) and ***Series Circuits*** (30 seconds). Be prepared to project them.
- ☐ Gather these materials (per student). See page 44 for suppliers.
  - 3-volt motor (the kind with gear attached to shaft)
  - AA battery in a battery holder
  - cardboard
  - rubber faucet washer (¾-inch or larger)
  - paper clips
  - duct tape
  - wire strippers
  - aluminum foil
  - 2 craft sticks
  - hook-up wire (e.g., 22-gauge, stranded)
  - paint stirrer
  - Ping Pong ball
  - scissors

1 Introduce the challenge (5 minutes)

- Tell students that today's challenge is to design and build a kick stick, which they can hold in their hand and use to kick a Ping Pong ball across the floor.
- Show the ***Just for Kicks Challenge*** video in which the *Design Squad* teams invent automatic ball kickers to help a professional soccer team practice.
- Discuss similarities between the *Kick Stick* challenge and the automatic ball machine from the *Design Squad* clip. *(Both send a ball flying, use batteries, motors, and circuits, are useful, and are a lot of fun.)*
- Show the ***Series Circuits*** animation. Take a moment to review the basics of electric circuits, such as open and closed circuits, series circuits, and switches.

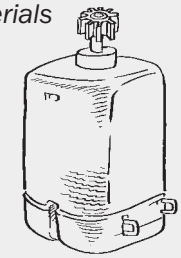
2 Brainstorm (10 minutes)

Brainstorm the circuit

- Show how the battery and motor work by connecting them and running the motor. Ask students to direct you in tracing the path of the electricity. *(They should tell you to start at the negative battery terminal, run your finger along the wire to the motor, and then exit the motor and follow the other wire to the positive battery terminal.)*
- What happens when there's a gap in the circuit? *(The current stops flowing. Review the terms open and closed circuits.)*
- How does a switch control whether a circuit is open or closed? *(Switches open and close a gap in a circuit.)*
- Is this circuit wired in series or parallel? *(Series, because the current travels a single path as it goes from the negative to the positive battery terminal.)*
- The paint stirrer is the "stick" part of the kick stick. Can you attach the battery and motor anywhere to the paint stirrer and still make a circuit? Explain. *(Yes. As long as there's an unbroken conducting path, electricity can flow from one terminal to another. Since proximity doesn't matter, the components can go anywhere: top, bottom, front, back, next to each other, or far apart. Students can use wire to bridge any gaps.)*

Brainstorm the design process

- Brainstorm how you could use a spinning shaft to get a Ping Pong ball moving. *(Attach a blade or set of blades to the shaft so they can hit a ball when the motor spins.)*
- Look at the materials you have for making the blades. What are the materials, and what are their strengths and weaknesses? *(Stiff blades [craft sticks, paper clips] as well as softer duct-tape strips [rolled tightly] can firmly kick a ball. Point out that while tape is soft, it can deliver a lot of force when it spins quickly. Encourage students to experiment with the different materials to decide what to use for blades and how to orient them.)*
- The motor's shaft is tiny. The large washer slips onto the gear and spins when the shaft spins. Brainstorm ideas for attaching blades to this washer. *(The washer provides a wide platform that students can tape their blades to.)*



Brainstorm the engineering

- Engineers create and improve things that matter to people. Why are games important? *(People love playing games, whether they're card games, board games, or video games. The message is: Making games matters because games entertain people.)*

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 kick stick? *(Where to put the battery and motor; how to turn it on and off; how to build a working circuit; what material to use for the blades; how to attach the blades to the motor; and how to attach everything to the paint stirrer)*
- 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 kicker that can kick a Ping Pong ball. 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:

- **Duct tape is hard to tear:** You can speed students' progress by demonstrating how to tear duct tape. You can also tear strips in advance and put them at the tables.
- **The washer doesn't fit:** If the washer hole is too large to fit properly on the motor gear, wrap a tiny piece of duct tape around the gear. Adjust it until the fit is snug.
- **It's hard to connect wire to the motor:** Straighten the motor contacts, but do it gently to avoid breaking them off.
- **Switches are unreliable:** 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.

Next, using a paint stirrer as the stick, students attach batteries, motors, and wires. Each design is unique.

Finally, students test their kick sticks by hitting Ping Pong balls across the floor, playing games they invent.