HEADPHONE HELPER CHALLENGE

The Challenge: Add a headphone to your instrument to make it easier to hear.

Preparation

- ☐ Copy the *Headphone Helper* handout (one per student).
- ☐ Visit pbs.org/designsquad and download the following video clips from the "Teacher's Guide" page: ***Rock On Challenge*** (1 minute) and ***Design Process: Teamwork Issues*** (3 minutes). Be prepared to project them.
- ☐ Make a simple string telephone (two cups connected by a string).
- ☐ Gather these materials (per student). See page 44 for suppliers.
  - *Build a Band* instruments
  - 2 paper cups (6 ounce or larger)
  - thin string (e.g., kite string)
  - large paper clips
  - scissors
  - duct tape
  - paper-towel tube or, even better, a 3-foot section of a wide plastic hose (e.g., sump pump discharge hose, which is 24 feet long, flexible, inexpensive, and readily available at hardware and home supply stores)

1 Introduce the challenge (5 minutes)

- Show ***Rock On Challenge***. Ask: How is what you're doing similar to what the *Design Squad* teams do? *(Both groups have to build original stringed instruments out of everyday materials that can be tuned and play a range of notes.)*
- Ask students: What are some ways to improve the instruments you built in *Build a Band*? *(Answers will vary, but increasing the volume will likely be mentioned.)*
- Tell students that today's challenge is to add a headphone to their instrument to make it easier to hear it.

2 Brainstorm (10 minutes)

Brainstorm sound energy

- What could you use to help carry sound waves from your instrument up to your ear? *(A tube; a string telephone with one end attached to the instrument; a stethoscope; an electronic system with a pickup; a radio system with a transmitter; etc.)*
- Explain that headphones work by picking up an instrument's vibrations. Hold up a student's instrument and have the class trace the path that sound travels from the string to the ear. *(Some of the string's vibrations travel directly into the air. They also go through the bridge and into the box, table, and air. These vibrations then travel through the air to the ear. Mention that materials and designs that absorb or dampen vibrations, like a bulky bridge or excess tape, reduce the volume.)*
- Show students your string telephone, and point out that sound waves travel through a solid—the string. Have students trace how the sound travels. *(The voice produces sound waves that travel into a cup and get the string vibrating. The string carries these vibrations to the second cup. This cup begins vibrating and moves the air in and around it, reproducing the original sound, which can be heard by the person holding the second cup.)*
- Show students a length of tubing and ask: How does sound travel through an air-filled tube? *(Sound energy vibrates the column of air trapped in the tubes. The vibrating column of air vibrates your eardrums, reproducing the sound.)*

Students pinpoint where their instrument vibrates a lot and attach a tube or string telephone to carry the sound waves directly to their ear.

One team used a string telephone with a double string to capture twice the number of vibrations.

A tube can carry sound waves. Students can attach it to the surface or insert it into the box.

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

Brainstorm the design process

- Show ***Design Process: Teamwork Issues.*** Ask: What are some strategies you can use to make sure all team members are included? *(Ask for ideas; agree on a plan; choose roles; assign tasks; use people's strengths; etc.)*
- Brainstorm ways that enable a string telephone or tube to trap as many vibrations as possible. *(String telephone: Use more than one string; use string that vibrates well; attach the strings firmly to the box. Tube: Add a cup to one or both ends as a sound collector. Both: Attach to a place on the instrument where there's lots of vibration, such as next to or under the bridge; keep the string or tube length as short as possible, because sound diminishes with distance.)*

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 design your headphone system? *(What kind of headphone to make; where and how to attach it; how to get the headphone to pick up the instrument's vibrations; whether to add a headband or an earpiece, such as a cup at the end of the tube; etc.)*
- 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 headphone system. 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:

- **Reattach strings:** Give students time to retape the strings on their instruments if the tape let go overnight.
- **Maximize vibrations:** To avoid dampening the vibrations, encourage students to use as little tape as possible, avoid using a bulky bridge, and keep the headphone from interfering with the strings' movements.
- **Keeping the string telephone's string tight:** Students can add weights or have a partner hold down the instrument to keep it in place.
- **Attaching the tube:** Students can tape the tube to the box or cut a hole in the box and insert an end into the air space.