Hands-On Activity

Waterwheel

In this activity, students will construct a model waterwheel to harness the energy in hydropower and transform it to mechanical energy. They will make some observations about the speed of their waterwheel, gather and record data, then interpret the data.

Safety note: if using a hot glue gun, goggles should be worn and a heat resistant work surface is recommended.

Materials:

- For each group:
  - stiff cardboard or foam core, about 15" x 15"
  - push pins or strong glue (hot glue gun ideal)
  - pencil
  - protractor, 6" diameter
  - wooden skewer, dowel, or straw
  - scissors
  - ruler
  - large basin, bucket, or access to a sink
  - pitcher of water

Students should work in small groups and use the following instructions to construct the waterwheel.

- Use the ruler to draw a line down the shorter side of the cardboard about 2 inches from the edge. Then use the ruler to divide that section into nine segments 1.5 inches wide. Use scissors to carefully cut out these segments. These are the waterwheel's paddles.
- Use the protractor to trace two circles on the remainder of the cardboard. Make sure to mark the centers of each circle using the protractor. Use a pencil or scissors to carefully punch a hole in the center of each circle. Use scissors to carefully cut out each circle. These circles will form the sides of the waterwheel.
- Use one of the circles to measure and mark the location of each of the paddles of the waterwheel. Using the protractor, measure 40° intervals along the edge of the circle and mark each interval with the pencil. Then, use the ruler to draw lines from each interval to the center of the circle. The lines should look like the spokes on a bicycle wheel. (If students don't know how to use a protractor to measure an angle, have them experiment to see if they can figure it out for themselves. Also, students who do know how to use the protractor can help students who are struggling.)
- Affix the paddles to the waterwheel by gluing or pinning the short side of a paddle to one of the lines or "spokes" of the wheel. Continue until all 9 of the paddle are glued to the wheel. Hot glue

or a strong adhesive will work best. Pins will also work well. Students should use caution with hot glue and pins.
- Affix the other side of the waterwheel by gluing the circle to the exposed sides of the paddles. Make sure that the circles line up so that the holes in the centers are aligned.
- Give the waterwheel an axle by inserting a skewer/dowel/straw through the holes in the centers of the sides.

Once students have constructed their waterwheels, they should create a diagram of the model in their notebooks, with all the parts labeled. They should practice gently spinning the wheel on the axel by holding the axle on each end and letting the wheel spin free between. If the wheel does not spin smoothly and easily, they should bore out the center hole a little bit.

Once the wheel is spinning smoothly, students will investigate the transformation of hydropower into mechanical energy. With one student holding the waterwheel over a sink or basin, another student should carefully pour water onto the paddles of the waterwheel. All students should make observations and record data about how the water turns the wheel. Have students investigate the factors that control the amount of hydropower available. Students should refer to the Exploration to come up with ideas and then record them in their notes. . Remind students that one of the hallmarks of a scientific investigation is that of controlling variables, both independent (test) and dependent (responding) variables. By systematically changing one variable at a time an investigator is able to study that variable's effect on a system or phenomena as a whole.

For example, in this activity, students might want to investigate how the height from which water is poured onto the wheel affects the speed at which the wheel turns. Ask students what the independent variable is in this case *(the height from which water is poured)* and what the dependent variable is *(the speed the wheel turns).* Can students suggest other independent variables for this system? *(the volume of water poured on the wheel, the location at which water contacts the wheel).*

Students should develop a few testable questions and then proceed with their investigations. They may want to record their data in a table like the one below.

Drop Height (inches)	**Spin Speed**
1	Slow
5	Faster
10	Fastest

If there is time or interest, students can expand the investigation by exploring how the mechanical energy of a hydropower-drive waterwheel can be transformed into electrical energy. Students should think about what they have learned about how hydroelectric plants use hydropower to spin turbines that drive generators. How can their waterwheels be used as a turbine? They should think about which mechanical part of the machine can be used to transfer energy. For example, the axle is spinning but no energy is being transferred. What would happen if another part was attached to the axel? Would it also spin? How could that energy be transferred to a generator? Students should develop ideas for an investigation. They may also want to watch the conclusion of **How Hydroelectricity Works** (start at 4:36) for ideas.

At this point, ask students to articulate how they went about investigating the effect of water drop height on the speed of their spinning waterwheel *(they carried out an experiment using a model waterwheel and water.)* Can students think of other ways to conduct an investigation besides doing an experiment, as they did in this activity? Encourage them to consider a variety of scientific questions they might want to answer, not just ones relating to waterwheels. Briefly discuss other forms of scientific investigation they might think of: observations, surveys, collecting specimens, describing and classifying objects and/or organisms, making models, and seeking information from resources.

Conclude this Hands-On Activity with a short discussion of the role of models in science. Appropriate questions might include: What are the characteristics of a scientifically accurate model? What size or scale are models usually? How are models useful? In regards to the waterwheel models students made, what were some of the limitations or disadvantages of their models? What were some of the benefits or advantages of their models?

Inquiry skills in this activity:

- Identify Questions
  - Recognize and develop testable questions that:
    - specify a cause-effect relationship
    - require the changing of one variable at a time.
    - can be answered with a science investigation or observational study.
- Design Investigations
  - Design and conduct investigations using:
    - Fair test - changing only one variable at a time makes comparisons valid
  - Make or use models that:
    - Simulate a real thing that cannot easily be studied or manipulated.
    - function exactly like or similarly to the real thing
    - Allow the testing of a hypothesis with results that can be extrapolated to the real thing
- Gather Data
  - Use Tools and the SI (metric) system to accurately measure:
    - Length/distance
  - Chooses appropriate tools to conduct an investigation
    - Ruler/tape measure
  - Uses sense to observe:
    - Seeing (color, shape, size, texture, motion)
  - Uses the appropriate format to record data:
    - Table
    - Sketch
- Interpret Data
  - Identifies and interprets patterns
    - Based on an analysis of data collected during an investigation
- Evaluate Evidence
  - Drawing and supporting a conclusion by:
    - Using data to determine the cause effect relationship observed in the investigation
    - Answer the testable question
    - Extrapolating results beyond the investigation
- Communication in Science
  - Report results using:
    - Table/graph showing data