



GOING FOR A SPIN: Making a Model Steam Turbine

PLANNING OVERVIEW

SUBJECT AREAS:

Physical Science, Math, Language Arts

TIMING:

Preparation: 30-60 minutes

Activity: 1-2 45-minute class periods

Note: "Going for a Spin" and "Getting Current" are best done in conjunction with one another.

Summary

Students explore how various energy sources can be used to cause a turbine to rotate.

Objectives

Students will:

- Recognize how the force of wind, falling water, and expanding steam can be used to do work.
- Create a model of a turbine and cause it to spin using the forces of wind, falling water, and expanding steam.
- Create a steam device that simulates some of the conditions of a steam-driven power plant.
- Use the scientific method to write up their work, including hypothesizing and drawing conclusions.
- Assess the ability of the turbine model to actually generate electricity.
- Use diagrams and narratives to describe how their apparatus worked and why.
- Compare their models to an actual power plant.

Materials

Per student group:

2 aluminum pie pans

Metal funnel, 4 inches (10 cm) in diameter

Scissors

Compass (for drawing circles)

Ruler

Pencils

Several plastic straws (the long soda type is best, but regular sized straws can be used)

Push pins

Small, thin washer (optional)

Small cooking pot, no bigger than 5 or 6 inches (13-15 cm) in diameter

Student Handout, "Going for a Spin," pages 4-7

Copy of Chapter 2 Discussion, "Energy and Electricity"

Student Handout, "Scientific Method Form," page 3 of the Appendix

For all groups to share at a "central station":

Hot plate(s) or other heat source(s)

Oven mitts

Source(s) of falling water, such as a faucet and sink, or a large jug or bottle of water and a bucket or tub

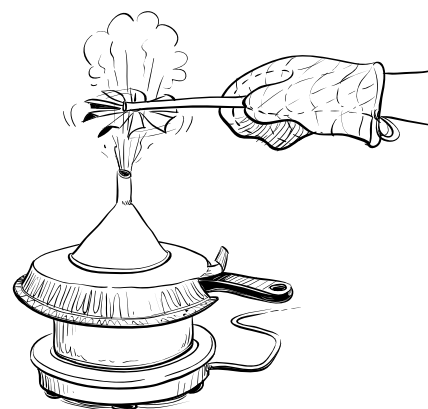
Towels for clean-up

Teaching Notes

Please review with your students all safety rules for working with heat and steam, particularly if you must use an open flame. Remind students to take care when cutting the aluminum pie plates.

This activity is intended for use in conjunction with the activity, "Getting Current." Each represents the two main functions of many typical power plants. However, each activity is designed to stand alone, if necessary.

The turbine model in this activity is not powerful enough to generate electricity, but it will successfully show students how different energy sources cause a turbine to spin. In "Getting Current" students will demonstrate how electricity is produced using electromagnetism. Though the two activities cannot be "connected" to produce electricity using the turbine model, students should be able to make a mental link between the two devices.





If you wish to do a more complicated project that shows a student-made turbine causing a generator to produce electricity, see the Tennessee Valley Authority materials listed in the Teacher Resources section of the Appendix.

Important Note: There are many different scientific method formats. The one suggested here is very basic and you may prefer to use your own format. If your students are not familiar with the steps of the scientific method, then you may wish to explain the method further.

Warm-up

Ask students if they have tried to wade across a rushing river or into ocean waves. Perhaps some have stood near a large waterfall. Ask students to describe these experiences. Have students connect the force of moving water with the idea of using it to do work.

Next ask students about the power of steam. It may be more difficult for kids to picture how steam can be forceful enough to make something move. Have students relate their experiences with steam (steamy showers, tea kettle, geyser, or natural steam vent). Students may think of steam as a wispy vapor that is not very powerful.

Review Chapter 2, especially the idea that we can produce and harness steam in a particular way that makes it very forceful – enough to spin a turbine that can be used to do work.

Tell students that in this activity they will be exploring how we use wind, water, and steam to turn turbines. Remind students that in the generation of electricity, the sole purpose of making a turbine rotate is to spin a generator.

The Activity

1. Gather the necessary materials and set up your classroom to accommodate the activity. Refer to the Student Activity page for the specific procedure. Develop a plan for use of a “central station,” if needed.
2. Use the Chapter 2 Discussion information to discuss turbines and the various ways we can cause them to turn (wind, water, and steam).
3. Explain to students that power plant turbines are highly engineered devices that are designed to make the best use of the force of wind, water, or steam. In this activity, students make very simple turbines that will spin when blown on (“wind”), placed under falling water or held up to the homemade steam device.

Remind students that most power plants today use steam to spin their turbines, and review how steam-driven power plants work. Emphasize that in order for the steam at a power plant to hit the turbine with enough force, it must be confined, creating high-pressure steam, and then released through a small opening, bursting out and expanding at great velocity.

4. Distribute copies of the Student Activity page for “Going for a Spin” and review the procedure. Organize student groups and give out all needed materials. Explain, if needed, that some materials are shared and that groups will be taking turns using the heat source at the “central station.”
5. Once students have had a chance to look over the directions for constructing the turbine model and the steam device, and have a general idea of what they both look like, go over the instructions for using the Scientific Method Form on page 3 of the Appendix.



6. Once finished with all three tests of the model turbine, tell students to write up the activity. Have students stay in their groups for discussion and support, but ask each individual to write up his or her own description. Consult Student pages 4-7 for exact directions.

Wrap-up

Gather the entire class together and have groups share their experiences with their turbines and the three different energy sources. Discuss ways they adapted the turbine model to make it work best. Talk about whether the angle of the blades or the distance from the resource needed to be adjusted for different energy sources and why.

Have students share their predictions regarding whether the turbine model could actually produce electricity. Ask if they changed their predictions after working with the model. Discuss why they thought the turbine in this activity is being called a "model."

Relate the use of their "wind" and water to turn their turbine models to the use of actual wind and water resources for the production of electricity. Explain that in this unit they will be learning about the many interesting ways we can use different

energy resources to produce electricity without having to burn fuels. Remind students that there are also ways to produce electricity without using a turbine at all, such as with solar (photo-voltaic) cells or hydrogen fuel cells, but that in this activity we are concentrating on turbines – the most common method in use today.

Ask students to explain why the steam device worked the way it did. (In the steam device, the steam is confined in a small space and so is constrained from expanding in all directions. This creates high-pressure steam that forces its way out through the small opening of the funnel. When it bursts out of the small opening of the funnel, it rises and expands with great force.)

Ask groups how far from the opening they held their turbines to get the most spin. Guide the discussion to the idea that the expanding steam hits the blades of the turbine, causing them to turn. There is a certain point above the opening where the most expansion occurs, thus causing the most spin.

Next, review the various ways we can produce steam to turn a turbine. Direct the discussion beyond burning fossil fuels (the most common way). Points to

include are the use of fuels such as biomass (students may first think of wood, but explain that there are many other types of biomass), of steam that comes directly from the earth (geothermal), and of the sun's heat to boil water (as in the process of solar thermal).

If any students have completed the extra credit, have them share their descriptions. To carry this further, you might facilitate the building and testing of any of these student designs, or suggest it as extra credit homework, or as a science fair project.

Assessment

Students will have had the opportunity to:

- Create and test a model of a turbine as well as a steam-producing device.
- Draw conclusions regarding the use of wind, water, and steam as energy sources.
- Use the scientific method, including hypothesizing and drawing conclusions.
- Relate turbine models being driven by various energy sources to an actual power plant.
- (Optional) Suggest a "home-made" turbine design that would be useful for generating a small amount of electricity.

Permission was granted by the Tennessee Valley Authority to adapt portions of their junior high curriculum unit, "The Energy Sourcebook," for use in this activity.



GOING FOR A SPIN: Making a Model Steam Turbine

In this activity you will demonstrate how different energy sources can be used to spin a turbine. Remember that the sole purpose of spinning a turbine at a power plant is to rotate an electrical generator. The turbine in this activity is not strong enough to operate an electrical generator; however, you can still experience how the force of wind, water, and steam are used to make a turbine spin.

You will also be constructing a device that produces steam in a manner similar to that used at a steam-driven power plant. You will recall from the Chapter 2 Discussion that the actual steam production technology at a power plant is extremely sophisticated and produces steam at very high pressures. However, this activity works well enough to get the point across.

Be sure to review all the safety instructions found in the Student Preface before you begin this activity.

Materials

Per student group:

- 2 aluminum pie pans
- Metal funnel, 4 inches (10 cm) in diameter
- Scissors
- Compass (for drawing circles)
- Ruler
- Pencils
- Several plastic straws (the long soda type is best, but regular sized straws can be used)
- Push pins
- Small, thin washer (optional)
- Small cooking pot, no bigger than 5 or 6 inches (13–15 cm) in diameter
- Copy of Student Activity, “Going for a Spin”
- Copy of Chapter 2 Discussion, Energy and Electricity
- Copy of “Scientific Method Form,” page 185

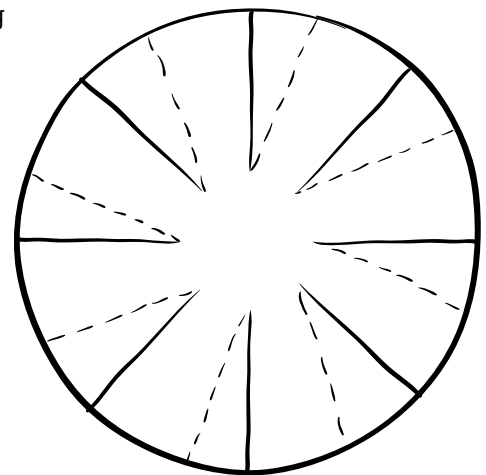
For all groups to share at a “central station”:

- Hot plate(s) or other heat source(s)
- Oven mitts
- Source(s) of falling water, such as a faucet and sink, or a large jug or bottle of water and a bucket or tub
- Towels for clean-up

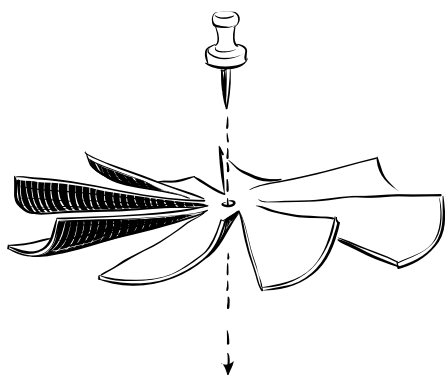
Procedure

THE TURBINE

1. Using your compass, measure and draw a 3.5 inch (approximately 8 cm) diameter circle with a pencil on one of the aluminum pie plates. Divide the circle into halves, then fourths, then eighths (marking the divisions by drawing your pencil down the straight edge of the ruler). As shown in the diagram, cut the circle into 8 blades by cutting along the 8 divisions on the solid lines, to within $\frac{3}{4}$ inch (2 cm) of the center. Make sure not to cut all the way to the center.

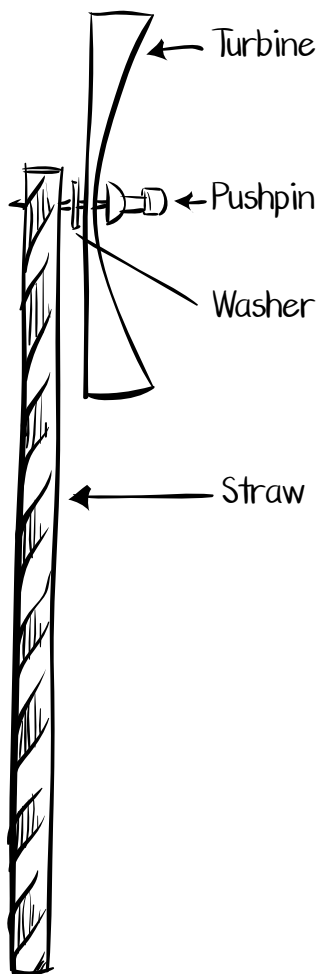


2. Taking each blade, bend one side gently up (along the dashed lines) so that all blades are curved up the same direction. (Pick a direction, such as clockwise, and stick to it all the way around). Don't overwork the blades at this point. You may need to make adjustments to the bend of the blades when you start using your turbine.



3. Using a push pin, attach the turbine to a straw at one end (illustration at right). Leave space (or insert washer, if needed) between the straw and the turbine, so it spins freely.

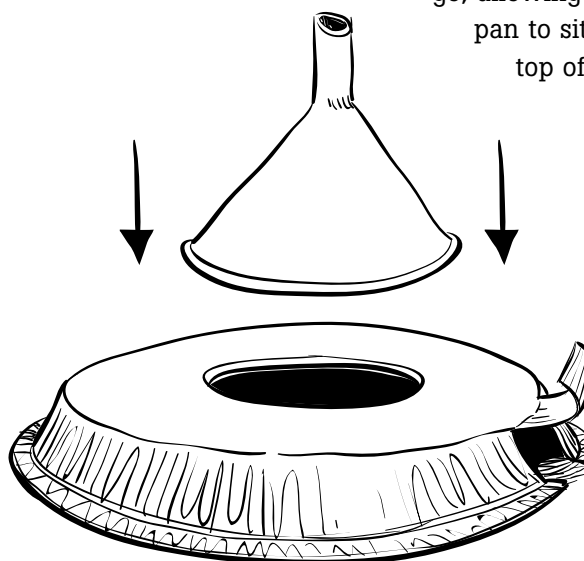
4. Next, construct your steam device (illustration at right), so that you will be ready when it's your turn to use the heat source(s) at the "central station."



THE STEAM DEVICE

1. Trace the circumference of the funnel onto the center of one of the aluminum pie pans. Using scissors, poke a hole in the center of the pan. Cut from the center out toward the edge of the traced circle, but stop about $\frac{1}{4}$ inch (almost 1 cm) from the circle itself. The line you traced is where the funnel will sit on the pie pan. The hole you are cutting must be smaller than this, so cut the circle about $\frac{1}{4}$ inch (almost 1 cm) inside from the traced circle. This way your funnel will sit on the pie pan without falling through and will cover the gap so that steam won't escape.

2. If necessary, cut a place on the edge of the pie pan where the cooking pot handle will go, allowing the pie pan to sit level on top of the pot.





THE SCIENTIFIC METHOD FORM

Before testing your turbine model and steam device, complete Steps 1 through 3 that follow. Remember that each student should do his or her own write-up, though you are doing the experiment in a group.

1. You will be using the Scientific Method Form provided with this activity unless your teacher tells you to use a different experiment write-up form.
2. For the Research section, unless your teacher indicates otherwise, you may summarize what you have learned from reading and discussing Chapter 2 about power plant turbines. Be sure to credit this book as the source of information.
3. For the Hypothesis, you should address the following:
 - a. Predict how well your turbine model will perform using the three “resources”: water, “wind” (your breath), and steam. For example, will the shape of the blades and/or their angle in relationship to the force of the resource affect the turbine’s performance?

When using steam, will it matter how far you hold the turbine from the opening that releases the steam? Will there be an optimal amount of “wind” to get the best spin?

Does it matter how far the water falls or at what angle you hold the turbine blades in the stream of water?

b. Predict whether you think this particular turbine model would actually be able to produce a small amount of electricity if it were connected to a small generator.

4. As you work on constructing and testing your devices using the directions in “Testing the Turbine (see page 7),” fill out the Procedure and Data sections of the form.

Since the directions are lengthy, be sure to summarize them for the Procedure.

For the Data sections, draw pictures showing your turbine using the three different resources (wind, water, steam). Make notes about how the turbine performed using different variations, such as varying heights of water,

varying “wind” speeds and distances from your mouth when blowing, different angles of holding the blades, and alterations to the shape of the blades.

For the steam test, be sure to include the height at which your turbine spun the fastest.

5. For the Conclusion portion of the form:
 - a. Compare the actual performance of the turbine to your predictions (hypothesis) regarding how the turbine worked with each resource. Make any other comments on what you learned while doing the tests, based on your notes from the Data section. Comment on why the authors have been referring to the turbine as a “model.”
 - b. Reassess your thinking in your original prediction as to whether the turbine could actually generate electricity.

TESTING THE TURBINE

1. Test your turbine by blowing on it, to simulate the energy of wind. Gently make adjustments to the turbine blades to get the most spin. Try varying the distance from your mouth or the force of your breath.

2. Test your turbine with a stream of falling water, making any needed adjustments for optimum spin. See how fast you can get the turbine to spin. Try varying amounts of falling water and varying heights from which the water falls before it hits the turbine.

3. Test your turbine using steam. Using the heat source, fill the cooking pot $\frac{1}{4}$ full of water and bring to a boil. Wearing oven mitts, place your steam device on top of the pan. Make sure that the funnel fully covers the opening in the middle of the pie plate. Steam should be issuing only from the funnel opening.

4. Wearing an oven mitt, hold your turbine "face" down over (but not directly on) the funnel opening. Remove the turbine and gently adjust its blades, if needed, to ensure optimum spin. Hold the turbine over the funnel opening again and raise and lower it slowly to see at which height it will spin fastest. Using the ruler, make an estimated measurement of the height from the funnel opening at which your turbine's top speed was achieved.

5. Stay in your groups to finish your experiment write-ups.

EXTRA CREDIT: Describe how you would design a turbine model that would actually be able to generate a small amount of electricity using a very small generator. If it worked, what electrical apparatus could it run?

