Lessons 1–3
Windmills at Work

Prepare

Lesson 1 begins with a discussion of students' experiences with wind. Students look at paintings and photographs of windmills and share their observations of how windmills might work. In Lesson 2, students are introduced to the story of William Kamkwamba, a boy who built a windmill to harness the wind and help provide his community with electricity and water. To see the power of wind for themselves, students build their own windmills and observe the transfer of energy. In Lesson 3, students create an anchor model to record their initial understanding of how windmills work. They then develop a driving question board that will guide student learning throughout the module.

Concept 1: Energy and Its Classifications

Focus Question

What is energy?

Phenomenon Question

How do windmills harness the wind?

Student Learning

Knowledge Statement

Everything that happens in a system is caused by energy.

Objectives

- Lesson 1: Make observations to generate questions about how windmills harness the wind.
- Lesson 2: Create a model windmill that generates electricity.
- Lesson 3: Ask questions about energy.

Texas Essential Knowledge and Skills Addressed

4.2A Plan and implement descriptive investigations, including **asking well defined questions, making inferences,** and selecting and using appropriate equipment or technology to answer his/her questions. (Addressed)

4.2D **Analyze data and interpret patterns to construct reasonable explanations from data that can be observed** and measured. (Addressed)

4.2F **Communicate** valid oral and written **results** supported by data. (Addressed)

4.3B **Represent the natural world using models** such as the water cycle and stream tables and identify their limitations, including accuracy and size. (Addressed)

4.3C **Connect grade-level appropriate science concepts with** the history of science, science careers, and **contributions of scientists**. (Addressed)

4.6A **Differentiate among forms of energy, including** mechanical, sound, **electrical, light,** and thermal. (Introduced)

4.6C **Demonstrate that electricity travels** in a closed path, **creating an electrical circuit.** (Introduced)

English Language Proficiency Standards Addressed

3C Speak using a variety of grammatical structures, sentence lengths, sentence types, and connecting words with increasing accuracy and ease as more English is acquired.

3E Share information in cooperative learning interactions.

4C Develop basic sight vocabulary, derive meaning of environmental print, and comprehend English vocabulary and language structures used routinely in written classroom materials.

Materials

		Lesson 1	Lesson 2	Lesson 3
Student	Science Logbook (Lesson 1 Activity Guide)	●		
	Pinwheel Investigation (per student): pencil, paper plate, pushpin, scissors	●		
	Science Logbook (Lesson 2 Activity Guide)		●	
	Materials from Snap Circuits® Green kit by Elenco® (per group): base grid, fan, motor, pivot stand base, pivot post, pivot top, black jumper wire, red jumper wire, red LED		●	
	Science Logbook (Module Question Log, Lesson 3 Activity Guide)			●
	Windmill model drawn in Lesson 2			●
Teacher	Windmill Gears Photograph (Lesson 1 Resource A)	●		
	Windmill Grinding Photograph (Lesson 1 Resource B)	●		
	The Boy Who Harnessed the Wind by William Kamkwamba and Bryan Mealer (2010)		●	
	Windmill Model Setup Instructions (Lesson 2 Resource)		●	
	Modern Wind Turbine Photograph (Lesson 3 Resource A)			●
	Wind Farm Photograph (Lesson 3 Resource B)			●
	Wind Farm Diagram (Lesson 3 Resource C)			●
Preparation	Open *Windmill, 1917* by Piet Mondrian: http://phdsci.link/1017.	●		
	Open *Oostzijde Mill with Extended Blue, Yellow, and Purple Sky, 1907–08* by Piet Mondrian: http://phdsci.link/1018.	●		
	Cue "Windmill Gears" video (andy b 2008): http://phdsci.link/1019.	●		
	Open maps of Africa and Malawi: http://phdsci.link/1158.		●	

Lesson 2

Objective: Create a model windmill that generates electricity.

Launch 5 minutes

Invite students to share their responses to Lesson 1's Check for Understanding question (What could you do if you harnessed the wind?) using a collaborative conversation routine, such as a Whip Around. Ask several students to elaborate by sharing why it might help to harness the wind in their chosen scenario; the goal is to reveal that harnessing the wind means to use wind power to make life easier.

Share with students that people had the idea that wind could make life easier hundreds of years ago when they designed the first windmills. Some early examples of such windmills were depicted in the Mondrian paintings students examined. Explain that people later learned how to use windmills to save lives. To learn how this is possible, students will continue exploring the Phenomenon Question **How do windmills harness the wind?**

Learn 30 minutes

Introduce and Discuss *The Boy Who Harnessed the Wind* 10 minutes

Share the maps of the continent of Africa and the country of Malawi (http://phdsci.link/1158). Explain that Malawi is heavily populated but one of the world's poorest countries. The country is less developed economically than most others, with little industry and limited money invested in education

Agenda

Launch (5 minutes)

Learn (30 minutes)

- Introduce and Discuss *The Boy Who Harnessed the Wind* (10 minutes)
- Construct Physical Models (20 minutes)

Land (10 minutes)

Extension

If students completed the Optional Homework from the previous lesson, consider opening this Launch by asking students to share any examples they found. This will create a natural bridge from the previous day's learning to the next.

Teacher Note

The Whip Around collaborative conversation routine gives each student an opportunity to share their response to a question. Consider having all students stand until they share. As students share, any students with similar responses can sit down or use another signal to indicate their response. For more information, see the Instructional Routines section of the Implementation Guide (3E).

and health care. Ninety percent of the population lives in rural areas, so agriculture is very important to people and the economy.

Ask questions to help students better understand life in a less developed country.

- **Based on what you know about the country, what types of challenges do you think people may face in Malawi?**
  - *They might not have enough food or water for everyone.*
  - *Kids may not be able to go to school. They may have to work to help their families get money for food.*
  - *They may not have electricity if it is a poor country.*

Share with students that only 1 in 11 people in Malawi have access to electricity (World Bank 2018).

- **Since most people in Malawi do not have electricity, what else might they not have access to?**
  - *They probably don't have lights.*
  - *I bet they don't have phones or TVs like lots of us do.*

- **What would happen if this country were to experience a drought?**
  - *There might not be food.*
  - *All the plants would die and then they won't have any food or money.*
  - *They might get sick without water to drink.*

Introduce students to *The Boy Who Harnessed the Wind* (Kamkwamba and Mealer 2010). Ask students to consider the following question as they listen to the beginning of the book: What steps will the boy take to help save his village by harnessing the wind? Read aloud the first part of the book through page 12. Stop reading after the sentence, "Windmills can produce electricity and pump water."

Lead a discussion with text-dependent questions such as the one that follows. As needed, reread relevant pages as students discuss their responses with a partner in a Think–Pair–Share.

- **In the last sentence, William wants to catch "magic." What "magic" do you think William is hoping to catch, and how will it help his family?**
  - *William thinks the wind is magic because it will help his family get electricity and water.*

Teacher Note

The Boy Who Harnessed the Wind does not contain page numbers. Pages 1 and 2 referenced in this module show the illustration of William holding a tool over his shoulder and text that begins, "In a small village in Malawi ..." Consider writing small page numbers in the text for reference.

Teacher Note

Think–Pair–Share is a collaborative conversation routine that allows students to share their response with a peer before sharing with the class (3E).

▶ **What steps will William need to take to save his village by harnessing the wind?**

- *He will need to find out where it is windy.*
- *He will need to learn a lot about how machines work.*
- *He will need to learn how a windmill harnesses the wind.*

Explain that William researched windmills at a library before building one in his village. Students now begin their own investigation into how windmills harness the wind by constructing physical models of windmills.

Construct Physical Models 20 minutes

Ask students to brainstorm the types of materials they would need to construct a windmill that generates electricity. Prompt them to think about what they know about electricity and what components electrical objects usually have. Students can record their ideas on personal whiteboards before sharing with the class.

Sample student responses:

- *We need fan blades and something tall for the base, like in the pictures.*
- *We need something to connect to the windmill, like a light or something that we can plug in to see if we have electricity.*
- *We might need wires or cords to connect the electricity.*

Explain that students will have access to kits that contain many of the materials mentioned, and they will work in groups to build physical models of windmills that generate electricity.

Pass out windmill model materials to each group and explain that the goal is to make the light-emitting diode (LED) light up. Encourage students to assemble the materials in different configurations to achieve this goal. See Windmill Model Setup Instructions (Lesson 2 Resource) for photographs of materials and proper windmill configuration.

Teacher Note

The size of these small groups will vary depending on class size. During materials preparation, determine how many groups you can support, and use that to select a grouping method that works best for your classroom.

Teacher Note

Students may need the following guidance when constructing their models (3E).

- The generator is a necessary part of the model. Allow students time to problem solve, but if they don't use the generator, guide them to use it.
- Explain that LEDs must be connected to the generator in a specific orientation (due to polarity). If the wires are reversed or do not form a complete circuit, the LED will not light up.

As students work, guide them to discuss and explore how and where the different components and wires connect. Once students develop a working model, introduce the term *complete circuit.*

▶ **What do you think the arrows on the LED mean?**

- *I think this is the path the electricity moves.*

Have students trace the complete circuit using their fingers.

Check for Understanding

As students develop their models, look for evidence of an early understanding of how the windmills work.

Evidence

Look for evidence that all students

- understand that the windmill's structure allows the blades to turn, and
- determine that wires (or cords) connect the windmill to the LED to allow electricity to flow.

Next Steps

Allow groups with a firm grasp on how to set up the windmill assist groups that have difficulty completing the task. Review each part of the windmill and ask students what they think the purpose of each part is and how it should connect to the other parts.

Land 10 minutes

Remind students of the Phenomenon Question **How do windmills harness the wind?** Ask students to draw a model in their Science Logbooks (Lesson 2 Activity Guide) to show how their physical model windmills harness the wind (i.e., use the wind to make something happen). Creating individual models will give students time to process their knowledge before sharing with the group. Next, students compare their drawings with those of other group members, revising their models and agreeing on a group model.

Content Area Connection: English

Use the word *circuit* to explore the Latin root *circ-*, which often means "around." Students brainstorm related words, such as *circle*, *circumference*, *circulate*, *circuitous*, and *circumstance*, and discuss how their meanings relate to the root. Challenge students to create sentences using *circuit* in both scientific and everyday contexts.

Teacher Note

To prepare students to investigate speed in a later lesson, check that students notice the correlation between the LED's brightness and the strength of the wind applied or the speed of the moving blades. If needed, follow up by asking more specific questions, such as What changes when the wind blows harder?

Differentiation

For students with graphomotor difficulties, consider providing pictures of different windmill parts and allowing students to glue them in their Science Logbooks, add labels, and explain their work.

When groups finish their models, ask students to share them with a partner from a different group. Students discuss similarities and differences between their models and record them in their Science Logbooks (Lesson 2 Activity Guide). Students may revise their models with any key components their partner shared with them.

To conclude the lesson, revisit the story of *The Boy Who Harnessed the Wind* and discuss how a windmill might help William.

- **How might building a windmill in William's village help his family get food?**
  - *Electricity will help William pump water to the farms from far away.*
  - *They might be able to use electricity to dig a deep hole and pump up water from the ground.*

Tell students that they will continue to learn how windmills can harness the wind and make life easier.

Optional Homework

Remind students that it is everyone's responsibility to conserve energy. Ask students to work with someone at home to examine how they use energy and create a list of ways to conserve it. Students should consider actions such as turning off lights that are not in use, turning the air conditioner to a warmer temperature in summer months and the heater to a cooler temperature in winter months, or walking, riding bikes, or taking buses to school and work instead of driving.