MACGILLIVRAY FREEMAN'S
DREAM BIG
ENGINEERING OUR WORLD

GRADE 4:

WIND-POWERED LED

Grade level: 4

Lesson length: 2.5 hours

The landscape is changing as we find alternative ways to meet our energy needs and rely less on fossil fuels. Hydropower from dams, wind power, solar power, wave energy, and even methane gas from sewage and anaerobic digestion processes are all examples of renewable, alternative energy sources that engineers are harnessing. Students will learn about one of these renewable energy sources as they design a wind turbine. They will test blade designs on a windmill and see if it can light an LED lightbulb.

In the Film

Engineers are leading the way as the world explores alternative energy sources to supplement or replace the fossil fuels humankind has come to rely upon. In the *Dream Big* film, we see engineers harnessing the power of the sun in the Ivanpah Solar Facility. In this facility, engineers have developed a system that converts the radiant energy from the sun into thermal, mechanical, and ultimately electrical energy. In this activity, students investigate another form of renewable energy, wind energy, and discover how engineers harness the power of our atmosphere to create energy for tomorrow.

NGSS Disciplinary Core Ideas

4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electrical currents.

4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

NGSS Engineering Practices

4-ETS1.C Optimizing the Design Solution

Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

Key Words/Vocabulary

Electrical energy: Energy of the movement of electrons through a circuit.

Mechanical energy: Energy of motion.

Materials

Per class:

- ☐ Box fan
- ☐ Pencil sharpener
- ☐ One KidWind Mini Turbine Kit (can be sourced from online vendors like Amazon; see Teacher Prep Notes for alternative)
- ☐ Windmill Blade Testing Device Instructions

Per team:

- ☐ Fan template
- ☐ Paper for taking notes
- ☐ Pencil or pen
- ☐ 2 corks
- ☐ Hot glue or thumbtacks
- ☐ Windmill Blade Testing Device preassembled:
  - ☐ Half-gallon milk carton
  - ☐ Water or other weight
  - ☐ ¼-inch by 1-foot dowel
  - ☐ Small paper cup
  - ☐ 1-foot length of string
  - ☐ Scissors
  - ☐ 2 metal washers
- ☐ Materials that may be used for making turbines:
  - ☐ 1 empty water bottle
  - ☐ Other scrap materials (e.g., soda bottles) for making turbine blades
  - ☐ 4 notecards, or cardstock
  - ☐ 1 foot of tape
  - ☐ 8 paper clips

Teacher Prep Notes

Though KidWind makes an excellent DC turbine that requires little to no assembly, it is not the only option. You can also buy a small DC motor, alligator clips, and an LED light. Attach the LED light to the DC motor using the alligator clips. When you spin the motor shaft, the LED light will illuminate. Similar to the KidWind motor, students' wind propellers are affixed to a cork, and the cork is pushed onto the motor shaft so that the spinning blades spin the shaft and generate light.

Before class starts, preassemble the testing devices for each team (see Research and Gather Information), according to the Windmill Blade Testing Device Instructions.

Be prepared to discuss the kinds of energy often used in society (radiant, electrical, thermal, mechanical, and so on) and have examples ready. Talk about how energy transfers convert energy to usable forms for humans. Have an explanation ready to explain how wind turbines convert mechanical energy (in the form of wind) to mechanical energy in the spinning of a turbine, to the electrical energy in the generator, to the radiant energy in a lightbulb.

To Do

Determine the Problem or Question to Solve: 15 minutes

1. Before watching the IMAX movie *Dream Big*, give students an overview of what they are about to experience. This film is about engineering and the ways that engineering can inspire, challenge, and enrich our lives. Give students the following questions to think about as they are watching the film:
   - ☐ What forms of alternative energy did you see in the film?
   - ☐ What are the benefits of having multiple sources of energy?
   - ☐ What role are engineers playing in the future of energy?
2. Debrief as a whole class after viewing the film. Allow students to reflect on the guiding questions you gave them. If necessary, remind students of some of the current challenges we face regarding the consumption of energy: dependency on nonrenewable fossil fuels, the byproduct of nuclear waste, greenhouse gas emissions, and so on.
3. Introduce the design challenge. Explain that in keeping with a worldwide initiative, many countries are exploring how they can reduce their dependency on fossil fuels such as coal, oil, and gas. Our planet provides many opportunities to harness energy with minimal impact on the planet, but so far the technology to harness energy from these sources on a massive scale has not been perfected. Out of the identified alternative sources, a few have risen to the top as showing the most promise: wind, solar, and tidal. Today students will use the provided materials—a KidWind Turbine with LED light (or similar materials as described in Teacher Prep Notes), a cork, and a turbine blade design of their choice—to design and build a wind turbine capable of generating energy.

Research and Gather Information: 60 minutes

1. Divide the class into teams of three.
2. To each group, distribute fan templates that students can use to create pinwheels. Have students cut along the solid lines and fold along the dotted ones. Instruct them to attach each pinwheel to the end of a cork with a spot of hot glue or a thumbtack.
3. Explain that the next step is to experiment with how air pressure can interact with the different predesigned wind turbine/pinwheel blades. Instruct each group to attach its pinwheels to their preassembled Windmill Blade Testing Device by poking the unused end of the cork onto the pointed end of the dowel rod. Place the windmills, with pinwheels attached, one foot away from a box fan. Turn the box fan on and let it blow on the pinwheels.

Students should record the amount of time it takes for each pinwheel design to raise the washers. Discuss with students the idea that the faster the pinwheel is moving, the more energy it is creating, and the faster it can raise the washers. For each of their three designs, students should note what worked well and what did not.

Review the kinds of energy often used in society (radiant, electrical, thermal, mechanical, and so on) and brainstorm examples of each. Talk about how energy transfers convert energy to usable forms for humans. Connect back to the wind turbines being built in class. They convert mechanical energy (in the form of wind) to mechanical energy in the spinning of a turbine, to the electrical energy in the generator, to the radiant energy in a lightbulb.

Plan a Solution: 15 minutes

If students are unfamiliar with the concepts of criteria and constraints in engineering, take the time now to introduce these two fundamental ideas. Engineers look at challenges through the lens of criteria (what does my device have to do?) and constraints (what are the limitations I face in making, testing, and using the device?). Spend some time as a whole class brainstorming the criteria and constraints of this particular engineering challenge.

Guide groups to identify one factor from each pinwheel design to use as inspiration for designing the blades of their turbine. Their goal will be to develop a design that will harness the most energy by spinning the fastest when air pressure is applied. Students should draw a diagram of what they plan to build, labeling the materials they will use and describing how energy is transferred to the lightbulb in the device.

Make It: 30 minutes

Give each group a baggie of materials and one cork with which to build the turbine blades. Blades can be made of paper, plastic, or another material. Allow students to build their designs, visiting each group and pushing them to fluently talk about their design, how it transfers energy, and how they will know if it is generating a lot of energy (more motion = more energy). The final blades should be attached to a cork for easy attachment to the turbine generator in the next step.

Test: 30 minutes

Attach each cork/turbine blade, one at a time, to the motor shaft of the turbine generator. Place a dot of hot glue on the cork before sticking it onto the turbine. This will ensure full contact so that it is spinning the motor as it spins from the wind. When you are switching groups, simply pull off the cork and the hot glue will easily peel off. Place the turbine at set lengths (e.g., one foot, two feet, three feet) from a box fan on low speed. Compare the input and output of energy from each stage.

Evaluate: 10 minutes

Ask students to reflect on the following questions and share their thoughts with the class:

1. Does your turbine spin effectively under airflow?
2. Does it hold up to the air pressure without breaking?
3. Does it produce enough electricity to light the bulb?

Taking It Further

Retest turbines at different fan speeds for each of the suggested stages.

Students can attempt to light multiple LEDs or use a voltmeter/ammeter to measure with greater accuracy.

Search the web for other pinwheel blade designs and templates.

Explore more ways that engineers are protecting our planet through innovations in alternative energies and in designing recycling solutions and strategies for cleaning up our planet.

Document your students' work through our social media outlet: #dreambigfilm

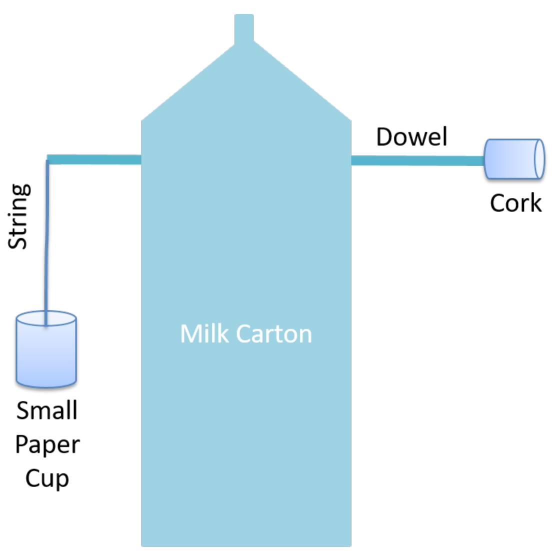
WINDMILL BLADE TESTING DEVICE

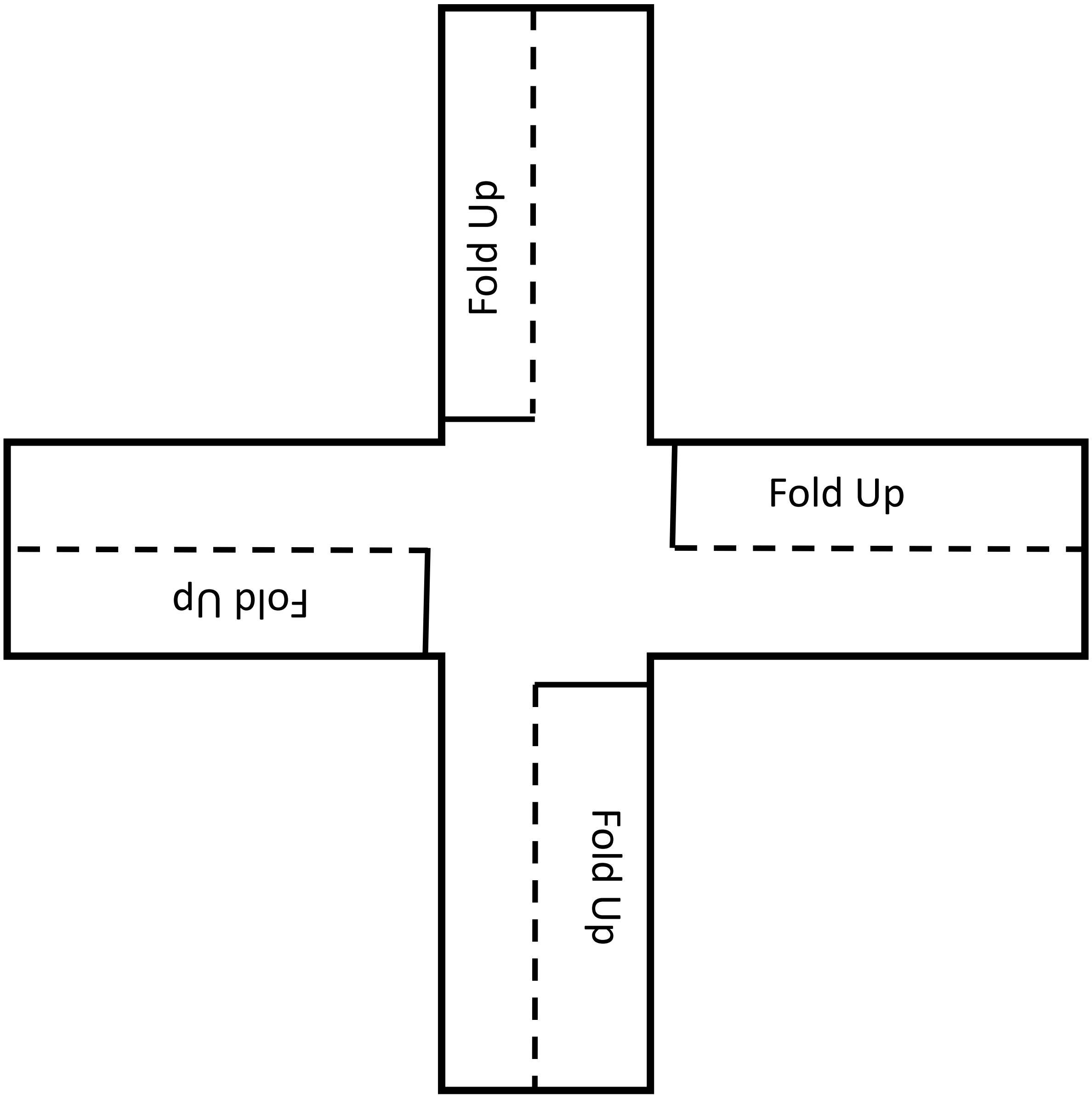
Assembly Directions:

1. Add water/weight to the milk carton (if using water, fill halfway).
2. Pierce the milk carton 2 inches beneath the top edge. Pierce the milk carton on the opposite side at the same relative location.
3. Sharpen a 1/4 inch by 1 foot wooden dowel rod by placing one end into a pencil sharpener. Place the dowel rod through the holes you made in the milk carton so that both ends are protruding on either side.
4. Tie 1 foot of string around the unsharpened end of the dowel rod.
5. At the loose end of the string, tie it to a small paper cup. This is most easily done by piercing the small paper cup with scissors near the top on either side, looping the string through, and closing with a knot.

Directions for Use:

1. Each group of students should have attached a pinwheel to one end of a cork before testing with this device.
2. Attach the blank end of the cork to the sharp end of the dowel by simply pushing the cork onto the sharp point until it is firmly stuck.
3. Place 2 metal washers in the paper cup.
4. Place the device 1 foot away from a box fan.
5. Turn the fan on and allow students to observe the turbine spinning and doing the work of raising the cup and washers!

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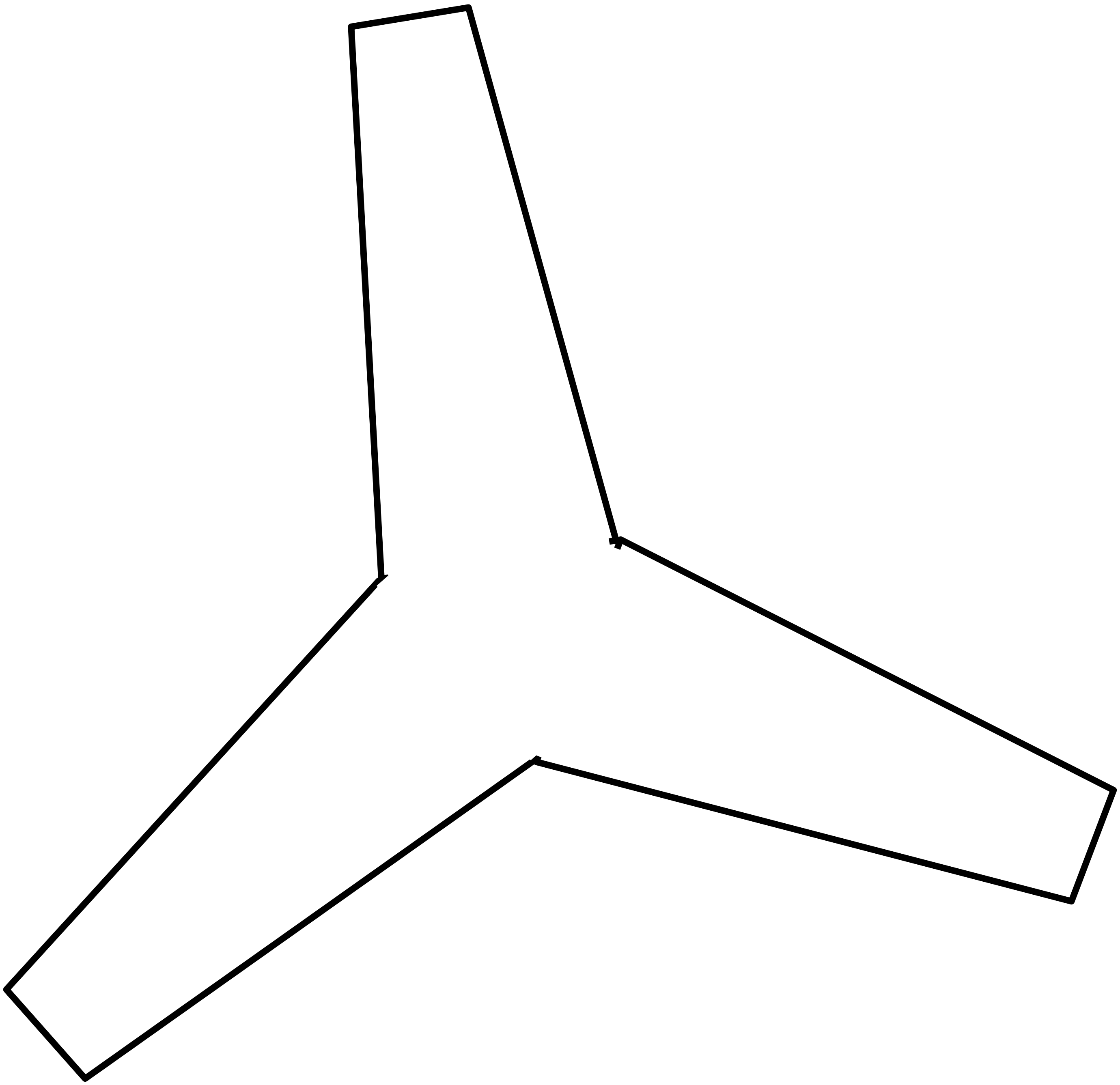

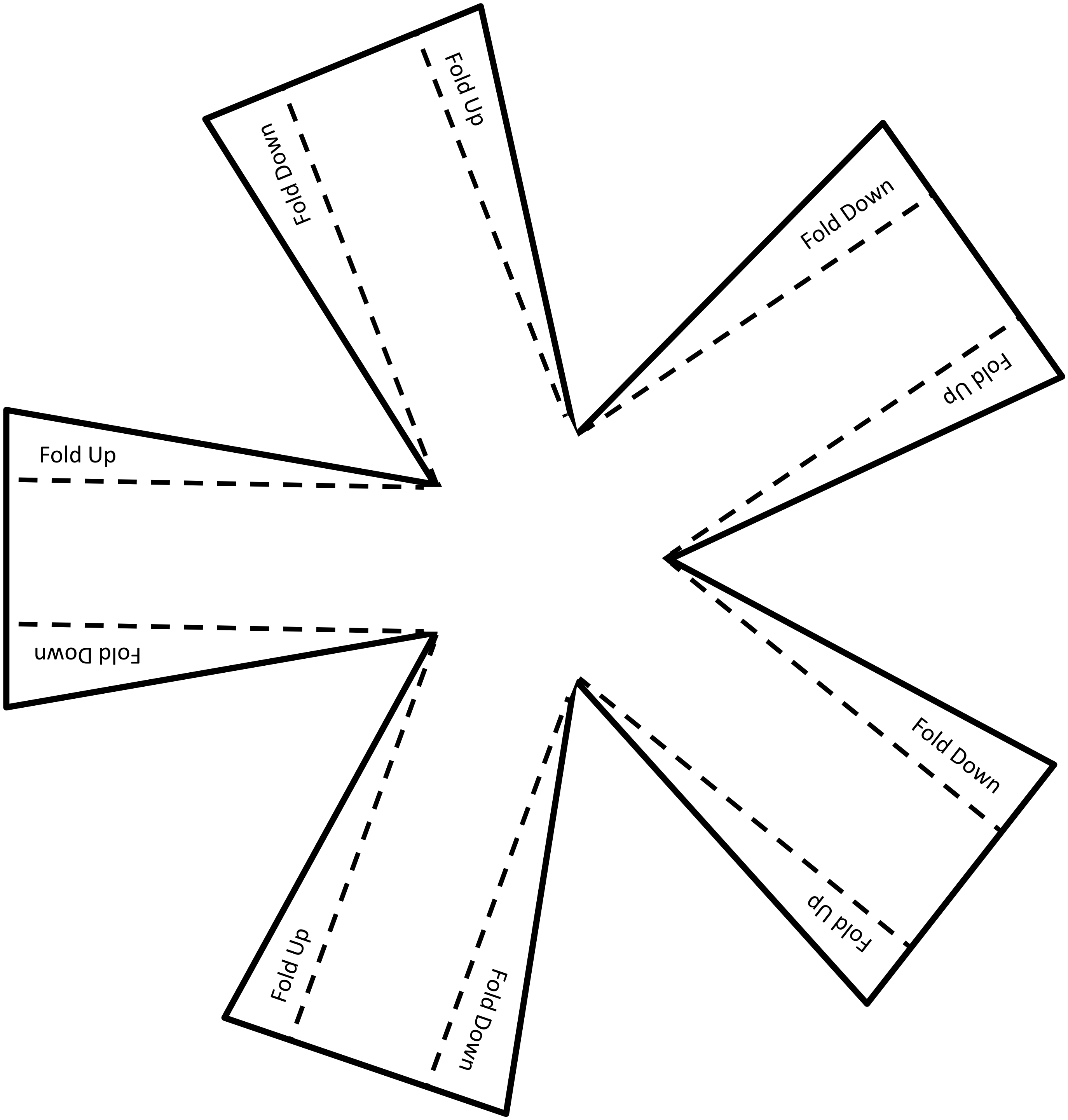
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If we can dream it, we can build it. Take a tour of some amazing structures designed by engineers, like a 1,000-foot glass elevator built on a cliff in China and a fire-breathing dragon that serves as a bridge in Vietnam. Visit the engineers who work from ropes suspended high above the Colorado River near Hoover Dam. Go to discovere.org/dreambig/media-assets and visit Educational Webisodes.