The Jamestown Windmill Companion Curriculum

Comprehensive lesson plans for educators designed to enhance a visit to the Jamestown Windmill

Welcome to the Jamestown Windmill!

We are Jamestown teachers who love exploring the Windmill annually with our 5th grade students. The recent enhancements to the Windmill exhibit will make your trip one you and your students will never forget. These lessons are meant to enrich your visit to the Windmill and are grounded in the ELA Common Core Standards for grades 5-8 to support your curriculum goals. (See appendix)

We hope you enjoy visiting the Windmill! Have Fun!

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Table of Contents

Lesson Plan 1:
Jamestown Windmill Informational Text Scavenger Hunt

Materials: *(all materials are available online at jamestownhistoricalsociety.org)*

1. Copy of the Jamestown Historical Society informational booklet, *The Jamestown Windmill*. (*online* or hard copy)
2. Student copies of Scavenger Hunt Questions (hard copy in Appendix A or as a *word document* on a laptop)
3. Answer Key Copy of Scavenger Hunt (projected for class view) (see Appendix A)

Time:

Approximately 90 minutes or 2 class periods. Time limits on hunt and number of questions to answer can be modified as needed for grade level needs.

Learning Objective: The students will:

1. Explore the features of non-fiction text
2. Understand the basic history and workings of the Jamestown Windmill
3. Collaborate to reach a common goal

Instructional Plan:

1. Activate Prior Knowledge: What is a Scavenger Hunt? Students generate ideas about this concept with an elbow partner. Teacher should make sure kids understand that a scavenger hunt is designed to challenge groups or individuals to collect items or facts in a limited period of time.
2. Divide class into triads with the following roles:
    a. **Scribe** (recording the group's answers to the Scavenger Hunt Questions)
    b. **Time Keeper** (keeps track of the 60 minute time limit for the hunt)
    c. **Speaker** (speaks for the team during the class share out)

    While the groups are collaborating and will submit one Scavenger Hunt response, it would be helpful for all group members to have access to the questions and the informational text.
3. Directions for Scavenger Hunt:
    "Working as teams you will read the informational text called *The Jamestown Windmill* and answer questions to help you to learn facts about the windmill as well as learn more about the features, or

characteristics, of non-fiction text. You and your team will have 60 minutes to answer 15 questions from the text."

As the groups work, circulate and listen to conversations. Guide groups who need extra support. Give a reminder at the 30 minute, 20 minute and 10 minute mark for the Time Keepers to check the time.

4. Class Share out: Call on the Speaker from each group to share answers. As the groups share out, record answers on the teacher copy of the class questions, projecting the answers as you write for student reference.

Assessments:

Teacher Observations, Class Post-Scavenger Hunt Discussion, Student written answers to Scavenger Hunt

Lesson Plan 2:
Close Reading – Informational Text
The Jamestown Windmill

Materials: *(all materials are available online at jamestownhistoricalsociety.org)*

1. Copy of the Jamestown Historical Society informational booklet, *The Jamestown Windmill*. Only the first section titled "History of the Jamestown Mill" (online or hard copy access)
2. If desired, type up questions to give to students. Otherwise, project questions using a document camera for class use as you go.

Time:

Approximately 1 Class Period or 60 minutes. Allow an extra period if you'd like the students to formalize their written answers.

Learning Objective:

The students will use Close reading to understand deeply the text and answer text based questions.

Background Information:

Close Reading is a central focus of the Common Core State Standards (CCSS). It requires students to get truly involved with the text they are reading. The purpose is to teach them to notice features and language used by the author. This lesson is designed around **Three Levels of Questioning**

- **Level One Questions:** The answers to these questions can be found explicitly in the text. These are most often who, what, when, and where kinds of questions. They work on the factual level and establish evidence of basic information.
- **Level Two Questions:** The answers to these questions are not found explicitly in the text—the reader has to infer, interpret, or analyze. They are what the text suggests but does not say. These are often how and why questions.
- **Level Three Questions:** The answers to these questions go beyond the text and are often found in parallel situations outside the text. The reader has to analyze, synthesize, and/ or evaluate, using the text as a guide to explore larger issues. They often require outside knowledge or experience to answer

Instructional Plan:

1. Pass out copies of the first section of *The Jamestown Windmill* History of the Jamestown Mill (could also be accessed online).
2. Share with the students that you will be reading this text multiple times. What are the benefits of reading and rereading unfamiliar texts?
3. Read the text aloud to the students. As they listen, students should begin to annotate the text. Possible annotations could be:
    a. Circle and put a question mark around unfamiliar or confusing vocabulary
    b. Put a ? in the margin and underline sentences which bring a question to mind- Parts that make the reader say “I wonder why..” or “I am confused by…”
    c. Use an exclamation point (!) to indicate parts of the text which interest or excite the reader.

    If you and your students have other annotations that work best for you, please use those.
4. Once you have read the text, ask students to read a second time, continuing to annotate as they read.
5. Conduct a class discussion as students share out their thoughts after the second reading. Clarify any vocabulary confusion.
6. Pose the questions below. Students will dig deeply into the text again to answer these questions. To facilitate discussion around these questions, use the *Think, Pair Share* strategy. As you pose a question, students think and write about the question for a few moments. Then they turn to their elbow partner to discuss the question. Finally, you can call on any pair to share their answers with the class. This strategy is an effective way to get kids to participate actively in the discussion and allows you to bring all students into a class share out because they do not know which pair you may select to share.
7. As a final step, you could ask students to go back and formally write up their responses to the questions. Or you may decide the discussion is sufficient to assess student comprehension.

Level One Questions:

1. Who bought the mill land in 1760? Why did he buy the land?
2. When did the townspeople of Jamestown ask for permission to build a new windmill? Who did they ask?
3. For how many years did the mill grind the dried kernels of white flint corn into corn meal?

4. How long was the mill neglected? What had happened to the mill? When did a group of Jamestown citizens decide to save the mill?
5. The mill is expensive to maintain. What is one way the Jamestown Historical Society gets money to maintain the windmill?

Level Two Questions:

1. What are three of the challenges to maintaining the mill? What is the author's purpose of sharing the challenges with the reader?
2. What are the three main parts of the mill building? These words are in bold. Why does the author choose to write these words in bold?
3. What three terms describe the Jamestown mill? How do these terms work together to give a strong description of the mill?

Level Three Questions:

1. In 1912, the mill was given to the newly formed Jamestown Historical Society. The society adopted the windmill as its logo and it is still the same today. Why do you think the logo was chosen and is still used today?
2. The Jamestown Windmill stands on a hill overlooking the Narragansett Bay. In the 100 years since the Windmill became the responsibility of the Jamestown Historical Society, what changes might the mill have "seen" on the bay?

Assessment:

Teacher Observations, Class Discussion, Student written answers

Extension:

Teachers could use the rest of the text to develop three levels of text dependent questions for further investigation.

Lesson Plan 3:
Windmill Photo Journals

Materials: *(all materials are available online at jamestownhistoricalsociety.org)*

1. Photos of Jamestown Windmill. These may be taken on a field trip or found online. Visit Jamestown Historical Society's online catalog at Jamestownhistoricalsociety.org for great pictures
2. Powerpoint, I-Movie, or other software or online resource for creating photo journals.

Time:

Approximately 3 Class Periods or 180 minutes.

Learning Objective: The students will:

1. Work collaboratively to create a photo journal about the Jamestown Windmill
2. Use technology to demonstrate learning and experiences
3. Present their journals to the class

Preparation:

1. The students will need to know a bit about the format you select for their journals prior to creating their own.
2. If you are doing this as a post-visit activity, be sure to have your students take lots of photos while at the Jamestown Windmill on their field trip. You could also take photos to share with students for this project.
3. This activity works well as a chance for students to collaborate so you may wish to pair students up to do the project.

Instructional Plan:

Class One:

1. Tell students they will be making a photo journal about the Jamestown Windmill.
2. Their journal should include 5 to 10 photos with captions.
3. The captions should convey their knowledge of the mill, its history, and how it works.
4. Also, the photo journal should be artfully designed and created.

Class Two:

Students continue to work on their photo journals to be ready to share them during the next class. The teacher circulates and assists as needed.

Class Three:

1. Partnerships share out their photo journals using a Smartboard or overhead projector. Allow 5 or so minutes per presentation.
2. Active Audience Participation: *3…2…1…Feedback*
   After each team presents its photo journals, the audience can write down the following:
   a. Three things I liked about your photo journal are:
   b. Two questions I have about your photo journal are:
   c. One suggestion I have for you next time is:
3. Allow time for questions and comments.
4. Final wrap-up- The teams can review the feedback from the other students about their presentations.

Assessment:

Teacher Observations, Final photo journal

Lesson Plan 4:
Exploring Contour Maps
Location, Location, Location!

Materials: *(all materials are available online at jamestownhistoricalsociety.org)*

1. Jamestown Windmill Journal for note taking and sketching. Stickers, given by teachers and chaperones for active journaling, work well to encourage all students to fill up their booklets.
2. Windmill Hill Topographic/Contour Map, Conanicut Island Topographic Map, Narragansett Bay Topographic Map, one per student. These may be attached as a page into the student journal.
3. Clip board and pencil per student for field trip.
4. *Best Locations for Windmills* diagram, one per student. See Appendix A or online.
5. Cornell Notes table for chosen best locations and evidence.

Optional Materials: Not necessary for contour/topographical map practice but relevant for continuation of lesson:

1. Articles or news on mechanical windmill use today, especially news of local wind-produced energy and related issues, pros and cons.
2. T-Chart for organizing pros and cons of wind energy issues.

Time:

Field trip to Windmill Hill and the Jamestown Windmill tour - 2.5 hours minimum, depending on number of students visiting.

Approximately 90 minutes or 2 class periods for using contour maps, mapping locations best wind use, and preparing and presenting arguments for chosen locations.

Learning Objective: The students will:

1. Gain rigorous geography practice of contour/topographic maps at a unique historical site connected to relevant issue of wind use. (NCSS)
2. Experience providing evidence for their thinking and ideas. (Common Core ELA, NCSS)
3. Prepare for and partake in a Shared Inquiry or Socratic Seminar of a relevant, local government and community related issue. (Common Core ELA, NCSS)

Instructional Plan:

1. Instruct students in contour maps, their uses, and how to read them.
2. Visit the Jamestown Windmill. At the mill and before entering it, each student locates the mill on a Jamestown contour map and marks the location of the Jamestown Windmill on their map with a small x, writing the elevation in feet above sea level as indicated by the contour lines of the map. Students may sketch the landscape and the windmill now, if time. Think, Pair, Share with a partner or two the reasons why this appears to be a good location for a windmill.
3. Tour the windmill guided by the Jamestown Historical Society docents. Students take journal notes as they learn more of the mechanics and requirements for this working windmill. Students have the opportunity to ask questions and record answers in their Windmill Journals.
4. Back in the classroom, students review *Best Locations for Windmill Diagrams* with attached quoted passage regarding best location. Students in small groups make observations and share discussions about what the diagrams teach them.
5. Using the diagrams and topographical maps, students find three other locations that might be a good location for a wind-powered machine – whether a windmill that uses the power mechanically or a wind turbine that generates electrical power. They mark these sites on the maps with an x, noting the elevations by reading the map.
6. Using the Cornell Notes table format, they identify each site in the left column and support with reason/evidence in the right column why the site is an ideal location for wind use technology, such as a windmill or wind turbine.
7. Students share one location each within a small group, listing evidence as to why the location would work. Any format for presentation that works for you.

Optional Extension:

1. Students, through reading local news and letters to the editor, interviewing family or townspeople, and attending local town meetings on wind power issues discover the arguments for and against wind energy use. These notes may be maintained in the Jamestown Windmill Journal.
2. Students create a t-chart listing the reasons for and against wind energy use to help explain why harnessing of the wind should be used more or why it should not.

3. After this investigation, students participate in a Shared Inquiry or Socratic Seminar on their findings and this issue. Questions to be addressed include:
    a. Why is wind power more contentious now than in the 18th and 19th century?
    b. What are the arguments against or for mechanical windmills, like the Jamestown windmill, today?
    c. What are the arguments against or for wind turbines that generate electricity?
    d. Why would Conanicut Island/Jamestown [or any location of choice] be ideal for a renaissance of wind energy?
    e. Is it worth the effort? Why or why not?

Assessments:

1. Final student-marked classroom contour/topo map and Cornell Notes table from site discussion/presentation
2. Final Jamestown Windmill Journal and further discovery/investigative notes for the Shared Inquiry or Socratic Seminar.
3. Shared Inquiry or Socratic Seminar participation, support, and evidence to responses.

Lesson Plan 5:
Jamestown Windmill: A Simple Machine
(But which one is it and how many more?)

Materials: *(all materials are available online at jamestownhistoricalsociety.org)*

1. Simple machines examples sheet: Appendix A or online.
2. Windmill Diagram of Jamestown Windmill: Appendix A or online.
3. Other Windmill Diagrams for comparison: Appendix A or download post mill and tower mill diagrams.
4. Materials for making a windmill: Appendix A or PBS Lesson Plan.
5. Jamestown Windmill Journals (Stickers as reminders to students to record observations, history, and make sketches, ask questions, etc.)
6. Clip boards and pencils for the field trip.

Time:

Approximately 120 minutes or 3 class periods:

1 class period with finding simple machines and comparing and contrasting diagrams;

1 class period for the experiment;

1 class period to complete experiment as necessary and share out observations of process;

Field trip to Windmill Hill and the Jamestown Windmill tour - 2.5 hours minimum, depending on number of students visiting.

Learning Objectives: The students will

1. Apply classroom knowledge to engineering design process. (NGSS)
2. Compare and contrast their engineered design to an authentic design of simple machines at the Jamestown Windmill.
3. Reflect on their engineering design process, working in teams, using information from failures toward creating a better design. (NGSS)
4. Compare and contrast different authentic designs with the same effort/work purpose. (NGSS)
5. Extend basic knowledge with a culminating Level 3 question. (Common Core ELA)

* Depending on how much time and writing you would like to include, there are opportunities in this unit for Common Core ELA practices.

(This unit connects well with the Jamestown Windmill contour mapping investigation lessons, extending the learning objectives that are built upon rigor and relevance of wind as work/energy topic)

Preparation:

The students complete the unit on recognizing basic simple machines and their uses and purpose.

Instructional Plan:

1. Students examine the diagram of the Jamestown Windmill to find as many simple machines as they can, circling and labeling them on the diagram. In pairs, share findings.
2. Students examine, compare, and contrast the diagrams of two other windmill designs. Students' findings are recorded on a compare (same) and contrast (different) chart or triple Venn diagram. Students respond to the question, "What is the simple machine that drives all windmills, the mechanism that is driven from the energy source of the wind in the sails?" (the wheel and axle)
3. Using the detailed lesson plan and materials in **Part II: Designing Windmills** and **Part III: Building Windmills** of the PBS **Making a Windmill** lesson plan, student work with one or two colleagues as engineers to plan a windmill design and then construct and experiment with the design. Students in their teams, using a science journal, must continue with a scientific method of recording successes and failures, sketching and labeling, redesigning. Success is not determined by whether or not it works well, but rather by discussion, trials, redesign, and communication. (If possible, filming the process will be valuable for students to reflect upon later.)
4. Students share – either orally or in a written question format – their process, what worked well for their group, and what needs improvement for next time (without blaming others). If observing a filmed recording of the class, all students can participate with respectful observations and critique of the process as it is rolled out for other groups.
5. Students visit the Jamestown Windmill to see the actual design and learn its history. With their Jamestown Windmill diagram, students find the simple machines and any more they may have missed. Students also learn the history of this magnificent structure, which they record through sketches, notes, comments, and questions in their Jamestown Windmill Journals.
6. As a wrap-up at the site, on their own, students respond to the Level 3 question: *Why is this a good location for a windmill. Make reference to the*

energy needed to move the simple machines to work. Be specific with reference to the wheel and axle. Be specific in describing the geography and necessary factors needed for a windmill to get the work done. Include a sketch of the landscape to help make your point. Reflection may need an extra half of a period. At the site and upon return from the field trip, students share responses through think, pair, share, or any sharing method or class app.

Assessments:

1. Jamestown Windmill Diagram with circled and labeled simple machines.
2. Triple Venn diagram or compare and contrast chart of three windmills.
3. Science Journal or Jamestown Windmill scientific process notes, diagrams, etc.
4. Personal written reflection of scientific process and experience as a whole.
5. Level 3 question response, looking for application and extension, of knowledge and effort.

Appendix A - Resources

Lesson Plan 1:
Informational Text Scavenger Hunt

Use the text, diagrams, and photos to answer the following questions. Your team will receive 1 point for each correct answer and 1 point for the correct location in the text.

Question	Answer	Location/Section in Text
1. The Windmill is located on what road in Jamestown?		
2. What historical site is right next to the Windmill?		
3. Who bought the land where the windmill stands in 1760? Who was he loyal to and why did he flee Rhode Island?		
4. When did the townspeople of Jamestown ask for permission to build windmill? Who did they ask?		
5. What was the condition of the grant of the land?		
6. What are the three main parts of the outside of the windmill? How did you know these words were important?		
7. What are the three terms that can be used to describe the Jamestown mill?		

8. What did the mill grind for 109 years?		
9. When did the mill close? Why?		
10. When was the Jamestown Windmill Association formed? Why?		
11. How often are major restorations required? Why?		
12. How many floors does the windmill have? What are their purposes?		
13. Examine the diagram of the mill. What are 4 parts of the windmill?		
14. How many grindstones are there? How much do they weigh combined?		
15. Examine the diagram in this section. How does the diagram help the reader understand how the grindstones work?		
16. What happens after the grindstones have been sharpened too many times?		
17. Why were the new stones put on the first floor?		

18. What are contained in the bonnet?		
19. How many teeth are in the ring gear?		
20. How is wind energy captured by the mill?		
21. How many revolutions , or turns, does the drive shaft make for each turn of the sail?		
22. What are the deep groves on the grindstones called?		
23. How long did it take the miller to disassemble, dress and reassemble the grinding stones?		
24. In 1787, what was the miller's fee for grinding one bushel (32 quarts)of corn?		
25. What might be the origin of the name Jonnycakes?		

Informational Text Scavenger Hunt- ANSWER KEY

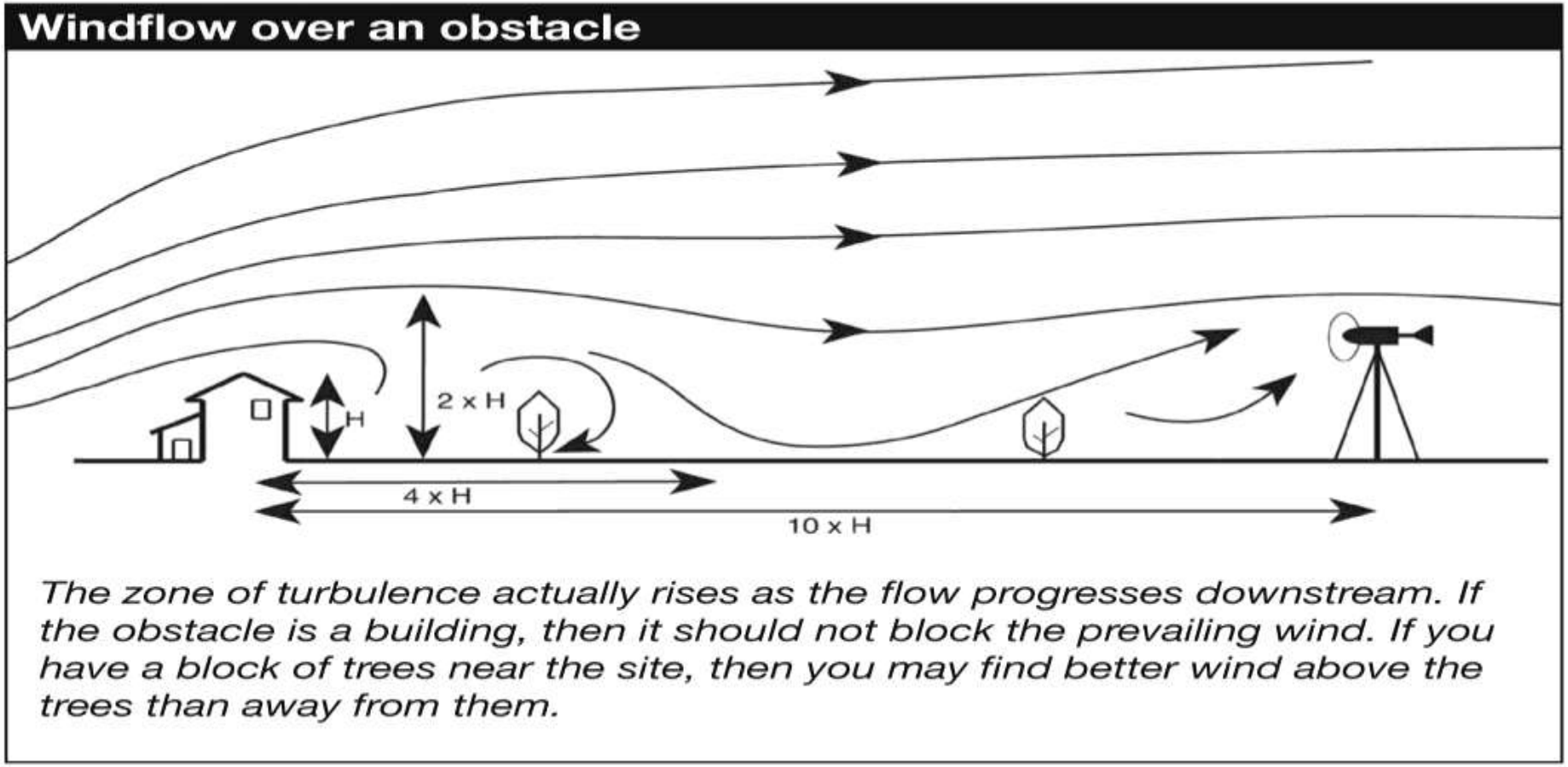
Use the text, diagrams and photos to answer the following questions. Your team will receive 1 point for each correct answer and 1 point for the correct location in the text.

Question	Answer	Location/Section in Text
The Windmill is located on what road in Jamestown?	The windmill is located on North Main Rd.	Map of Jamestown Historical Society Sites p. 1
What historical site is right next to the Windmill?	The Quaker Meetinghouse	Map of Jamestown Historical Society Sites p. 1
Who bought the land where the windmill stands in 1760? Who was he loyal to and why did he flee Rhode Island?	Colonel Joseph Wanton Jr. He was loyal to the British King. When the British occupation of Jamestown ended in 1779 he fled.	History of the Jamestown Windmill p. 2 Paragraphs 2 and 3
When did the townspeople of Jamestown ask for permission to build windmill? Who did they ask?	1787- the Rhode Island General Assembly	History of the Jamestown Windmill p. 2 Paragraph 4
What was the condition of the grant of the land?	"they erect and keep in repair a good windmill for grinding grain"	History of the Jamestown Windmill p. 3 Paragraph 1
What are the three main parts of the outside of the windmill? How did you know these words were important?	Bonnet (domed cap) sails and wind shaft- They are written in bold.	History of the Jamestown Windmill p. 3 Paragraph 2
What are the three terms that can be used to describe the Jamestown mill?	Windmill, gristmill and a smock mill	History of the Jamestown Windmill p. 3 Paragraph 3
What did the mill grind for 109 years?	Coarse cracked corn to fed animals and finer corn meal for people to eat	History of the Jamestown Windmill p. 3 Paragraph 4
When did the mill close? Why?	1896- The miller could not compete with the rolling mills of the west.	History of the Jamestown Windmill p. 3 Paragraph 6
When was the Jamestown Windmill Association formed? Why?	1904-The mill was in bad shape and needed to be repaired.	History of the Jamestown Windmill p. 4 Paragraph 1
How often are major restorations required? Why?	Every 15-20 years- beetles trying to eat the old wood, small animals and the destruction of the sails in storms.	History of the Jamestown Windmill p. 4 Paragraph 3

How many floors does the windmill have? What are their purposes?	Three Milling Floor- holds the grindstones Bin Floor- used for storage Dust floor- holds the equipment used to change wind into usable energy.	How the Mill Works p. 5 Paragraph 1
Examine the diagram of the mill. What are 4 parts of the windmill?	Answers vary	How the Mill Works p. 5 Windmill Diagram
How many grindstones are there? How much do they weigh combined?	Two 7,000 pounds	The Milling Floor p. 6
Examine the diagram in this section. How does the diagram help the reader understand how the grindstones work?	Answers vary	The Milling Floor p. 7
What happens after the grindstones have been sharpened too many times?	They wear thin and must be replaced.	The Bin Floor p. 8 Paragraph 2
Why were the new stones put on the first floor?	They were too heavy to be supported by the old structure.	The Bin Floor p. 8 Paragraph 3
What are contained in the bonnet?	There are gears in the bonnet to rotate it to catch the wind.	The Dust Floor p. 8 Paragraph 1
How many teeth are in the ring gear?	220 teeth to keep the bonnet turning freely	The Dust Floor p. 8 Paragraph 2
How is wind energy captured by the mill?	The cloths are raised on the sails capture the wind energy.	The Dust Floor p. 9 Paragraph 4
How many revolutions , or turns, does the drive shaft make for each turn of the sail?	5 revolutions	The Dust Floor p. 9 Paragraph 5
What are the deep groves on the grindstones called?	They are called furrows.	Dressing the Stone p. 10 Paragraph 4
How long did it take the miller to disassemble, dress and reassemble the grinding stones?	A full day of work!	Dressing the Stone p. 10 Paragraph 7
In 1787, what was the miller's fee for grinding one bushel (32 quarts)of corn?	He kept 3 quarts for himself.	The Millers Fee p. 12 Last paragraph
What might be the origin of the name Jonnycakes?	Some feel the name used to be journey cakes because the cooked corn cakes travel well and many can fit in a small sack.	Jonnycakes p. 13

Lesson Plan 4:
Exploring Contour Maps
Location, Location, Location!

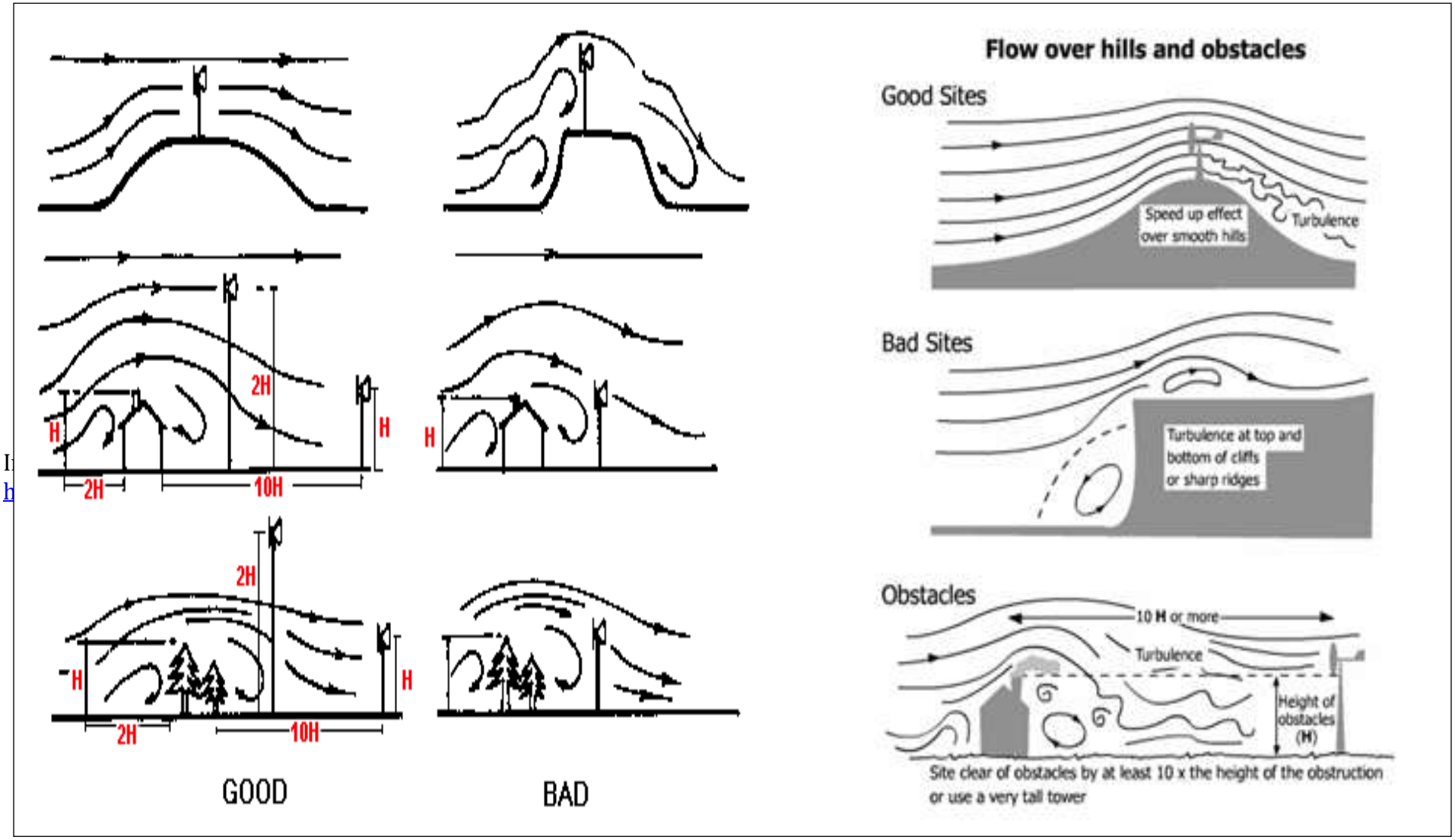
Best Locations for Windmills



Regarding location of a wind turbine, similarly,"…You can have varied wind resources within the same property. In addition to measuring or finding the annual wind speeds, you need to know about the prevailing directions of the wind at your site. If you live in complex terrain, take care in selecting the installation site. If you site your wind turbine on the top of or on the windy side of a hill, for example, you will have more access to prevailing winds than in a gully or on the leeward (sheltered) side of a hill on the same property. In addition to geologic formations, you need to consider existing obstacles such as trees, houses, and sheds, and you need to plan for future obstructions such as new buildings or trees that have not reached their full height.[1] Your turbine needs to be sited upwind of buildings and trees, and it needs to be 25 to 35 feet above anything within a 300-foot horizontal radius."[1]
Image from: http://info.cat.org.uk/sites/default/files/images/wind/Windflow_obstacle.jpg
Passage from: http://en.openei.org/wiki/Small_Wind_Guidebook/How_Do_I_Choose_the_Best_Site_for_My_Wind_Turbine

Windflow Over Different Obstacles and Contoured Terrain

Notice the different contours of the land and its effect on the wind flow.



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Lesson Plan 5:
Jamestown Windmill: A Simple Machine
(But which one is it and how many more?)

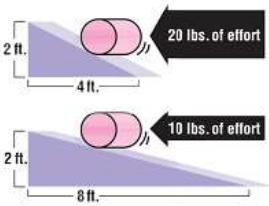
Simple machines examples sheet

Simple Machines

Cars and bicycles. Forklifts and cranes. Water faucets and even the flush mechanism on toilets. All of these are "complex machines" made by putting together combinations of 6 simple machines: the lever, wheel and axle, pulley, screw, wedge, and inclined plane.

KIDS DISCOVER

The **inclined plane** is the simplest of the simple machines. It is a fancy name for a flat, sloping surface. The most obvious example is a ramp. If you need to lift a heavy load to a higher level, the inclined plane can help.



Here's what happens to the amount of effort needed when you roll a 40-pound drum up these 2 ramps.

The **wedge** may be the original simple machine. It's mainly used for splitting or separating things. Think of the head of an axe. Thwack! You just divided that log in two. Imagine doing that with your bare hands!

Archaeologists have found wedges (in the form of stone hand axes) that were used by our pre-human ancestors 2.6 million years ago.

A **screw** doesn't look much like a machine. But it's actually one of the coolest machines around. A screw transforms energy from turning (rotational energy) into up-and-down energy. So by turning a screw, you can lift things up, push things down, and hold things together.

Wrap your mind around this! The screw is an inclined plane wrapped around a cylinder. On a screw, the inclined plane is called the thread.

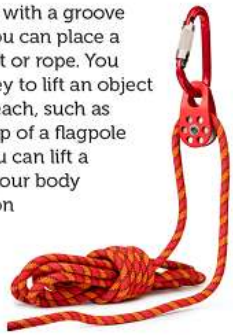
A **lever** is a straight bar or rod that turns on a pivot point, or fulcrum. You can use levers to lift heavy loads, pry things (like cans of paint) open, and hurl projectiles.

Seesaws, crowbars, bottle openers, baseball bats, and brooms are all examples of levers.

Life without the **wheel and axle**? Hard to imagine. They've been around for more than 5,000 years. The genius of the wheel and axle is that they can be used to push and pull heavy loads in everything from wagons to semitrucks. AND they can be used to operate mechanisms such as doorknobs and faucet handles.

The wheel and axle are everywhere you turn: Ferris wheels, doorknobs, screwdrivers, bike wheels and gears, skateboards, and more.

A **pulley** is a wheel with a groove in the rim in which you can place a cable, chain, cord, belt or rope. You can use a simple pulley to lift an object to a place you can't reach, such as raising a flag to the top of a flagpole or a sail on a boat. You can lift a heavy load by using your body weight to pull down on the rope.



When combinations of pulleys are put together, they can lift even heavier loads.

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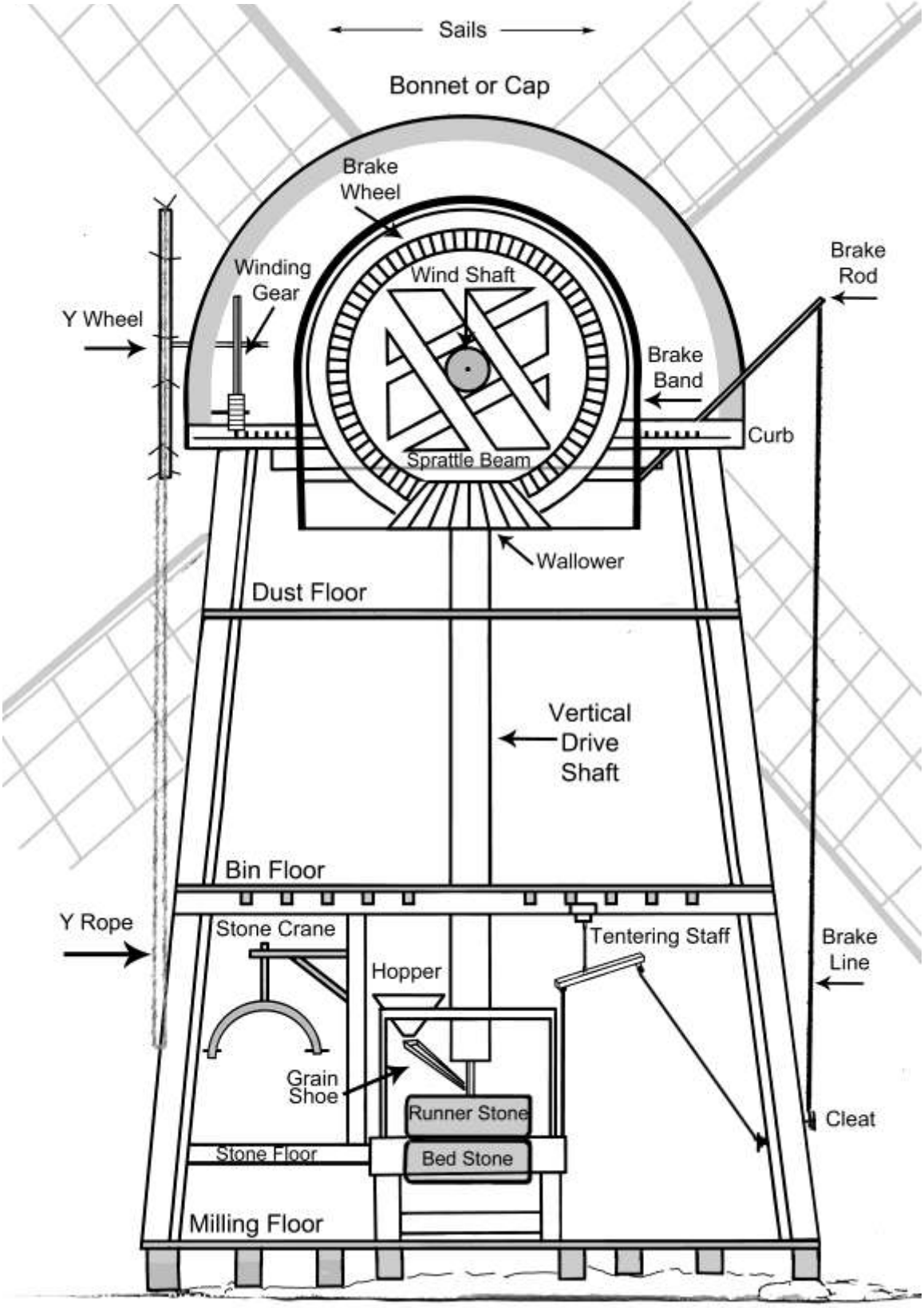
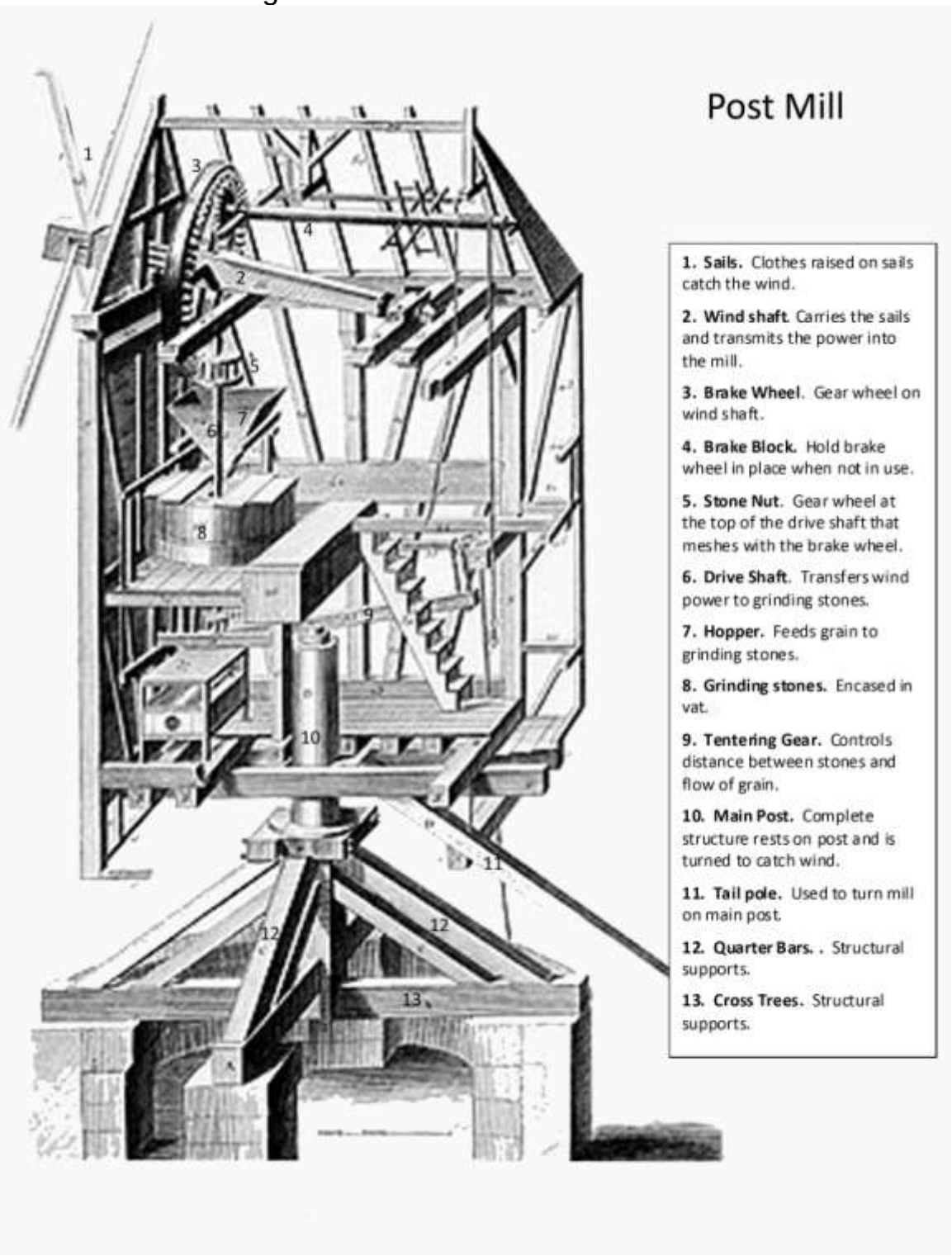
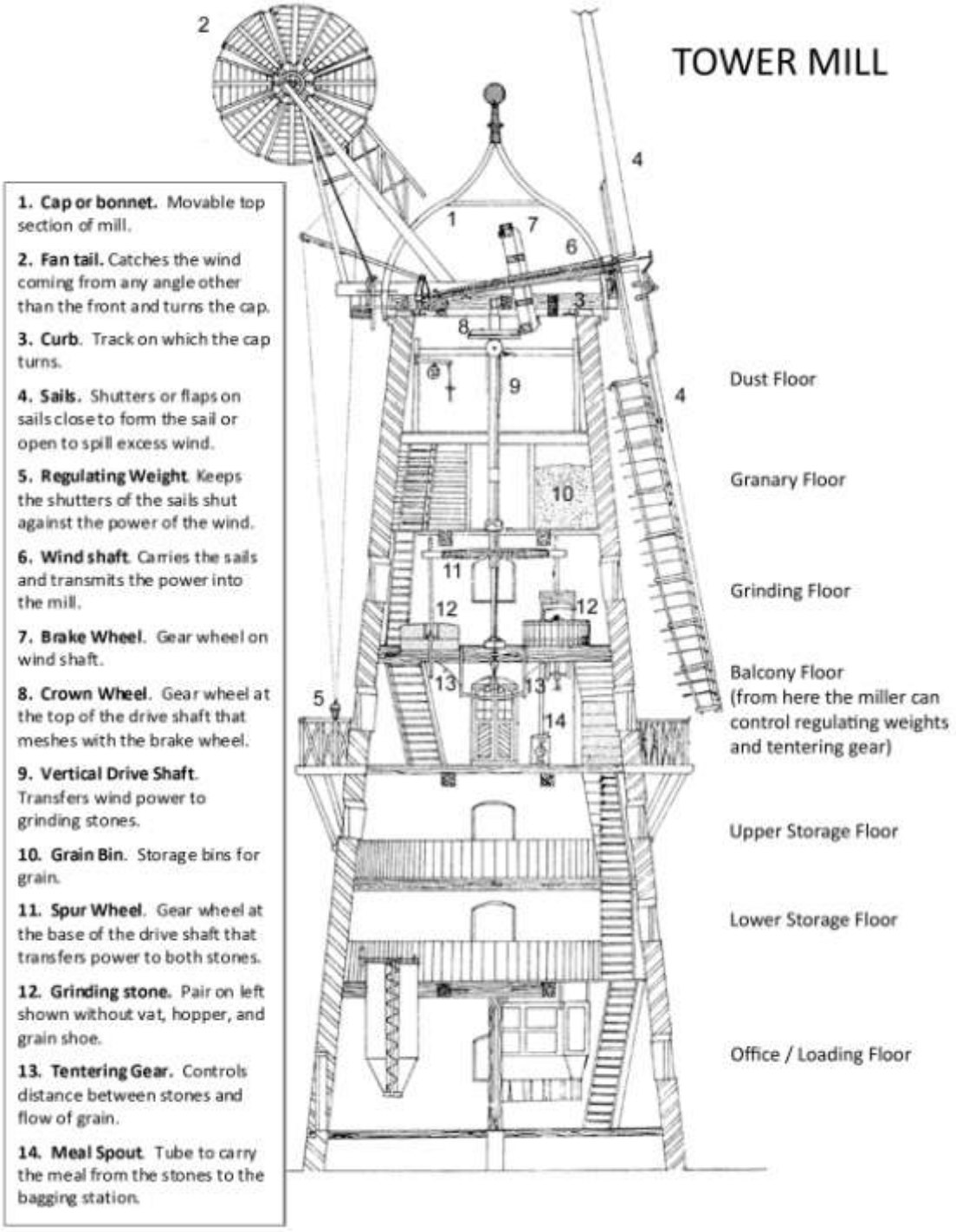
Diagram of Jamestown Windmill



Other Windmill Diagrams 1



Other Windmill Diagram 2



Lesson Summary: Making a Windmill

Overview

For hundreds of years, people have harnessed moving air (wind) to do work. The earliest forms of wind-powered machines were sailboats. Wind pushing against the sails of a boat provided the energy to move the boat across the water, saving people the trouble of rowing. Later, people discovered that if they attached sail-like panels to a wheel at the top of a stationary tower, wind blowing against the panels would cause the wheel and the central shaft to which it was attached to turn. The shaft drove mechanisms inside the tower that were used to mill, or grind, grain into flour. These wind-driven mills were called, simply, windmills. And even though wind-driven machines are now also used to pump water from wells and to generate electricity, the name *windmill* has stuck.

In this activity, students review the engineering design process and discuss how wind can be used to help get work done. They look at a variety of windmills, focusing on the different materials used in the construction of windmills and the type of work each windmill is designed to do. Finally, they use simple materials to build their own windmills to do work.

Objectives

- Understand the engineering design process (define the challenge, brainstorm and research solutions, choose a solution that fits within constraints, design and build a solution, test the solution, evaluate and redesign if necessary)
- Recognize that moving air can be used to power machinery to do work
- Identify how windmills have changed as new technologies and materials became available

Grade Level: 3-5

Suggested Time

- Three 50-minute blocks

Multimedia Resources

- What Is the Design Process? QuickTime Video
- Air Is Matter Flash Image
- Exploring Windmill Design QuickTime Video
- Windmill Gallery Flash Image

Materials

- Windmill Worksheet (PDF) handout (PDF)
- Windmill Template (PDF) handout (PDF)
- sheets of plain paper, 8 1/2 in. x 11 in. (22 cm x 28 cm)
- sheets of construction paper, 8 1/2 in. x 11 in. (22 cm x 28 cm) (if students want to make different-colored windmills)
- pencils or a single hole punch"
- scissors
- straws
- rubber bands
- paper cups

- string

Before the Lesson

- Print out a copy of the Windmill Worksheet (PDF) for each student.
- Print out the two different-sized patterns (5" and 7") featured in the Windmill Template (PDF) for each student. If you wish, you or the students can scale this up to an even larger square-edged dimension.

The Lesson

Part I: Exploring Windmills

1. Tell students that they will use the engineering design process to explore windmills. Lead a discussion about windmills to find out what students already know. Ask:

- Have you ever seen a windmill?
- What did it look like?
- What do you think it was used for?
- How do you think windmills work?

Note that correct answers are not required here; you are simply looking for a base level of understanding to start the activity.

Define the Challenge

2. Ask students to describe how windmills do work. (They convert wind energy to mechanical energy.) Brainstorm together to come up with a good description (e.g., converting wind energy into work to help people).

3. Lead a conversation about the engineering design process to find out what students already know. Show the video What Is the Design Process? and review the description that the class came up with in step 2. Ask:

- What part of the design process did you complete when you came up with the description? (They defined the challenge: to design a machine that uses wind energy to do work.)

As students go through the various steps of the design process, you may want to record the steps in a chart. This will give students an overview of the process and where they are in it.

Brainstorm and Research the Challenge

4. Tell students that they are now starting the brainstorming and research component of the design process. Have them view the Air Is Matter still collage, and encourage them to discuss the types of things that air can do. Ask:

- How is air able to do these things? (Air has mass and takes up space, air exerts pressure, air moves.)
- Where in their lives have they seen air do work?

Part II: Designing Windmills

Brainstorming and Research

5. Start by reviewing the design challenge that students came up with in steps 2 and 3 [to design a machine (windmill) that uses energy from the wind to do work].

6. Next, show students the Exploring Windmill Design video. Ask:

- How is the engineering design process reflected in the video?
- Are there any changes you would make to this design? Why?

Design a Solution(s)

7. Windmills have changed dramatically since their invention. Have students review the Windmill Gallery still collage and look for the following design features:
    - the tower (size, shape, materials used)
    - the blades (size, shape, materials used)
8. Lead a discussion based on their observations.

Part III: Building Windmills

Build a Solution

9. Pass out to each student a copy of the Windmill Worksheet (PDF), the two different-sized patterns featured in the Windmill Template (PDF), and the materials needed to construct their own windmill. Let students choose the pattern size they want to use. Encourage the class to use a variety of sizes.

Test and Evaluate

10. After the windmills are complete, have students test them to see if they accomplish the work of lifting the cup. After several minutes, ask:
    - What did you notice about the size of the windmill blades and how fast or slow the cup was lifted?
11. Lead a discussion about what design changes they would make if time allowed them to build another windmill. Ask:
    - How would you improve your design? (make the windmill blades larger or use something stronger than a straw for the shaft, etc.)

Check for Understanding

Discuss the following:

- Show the students the Windmill Gallery still collage again. How are the windmills similar to and different from one another? How are windmills similar to fans? How are they different from fans?
- What design challenges did students face when building their own windmills? What constraints did they have to overcome? How might the design challenges be similar or different for a fan?

Common Core Anchor Standards for Reading and Writing (www.corestandards.org)

Key Ideas and Details:

CCSS.ELA-LITERACY.CCRA.R.1

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

CCSS.ELA-LITERACY.CCRA.R.2

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

CCSS.ELA-LITERACY.CCRA.R.3

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

Craft and Structure:

CCSS.ELA-LITERACY.CCRA.R.4

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

CCSS.ELA-LITERACY.CCRA.R.5

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

CCSS.ELA-LITERACY.CCRA.R.6

Assess how point of view or purpose shapes the content and style of a text.

Integration of Knowledge and Ideas:

CCSS.ELA-LITERACY.CCRA.R.7

Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.[1]

CCSS.ELA-LITERACY.CCRA.R.8

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

CCSS.ELA-LITERACY.CCRA.R.9

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

Range of Reading and Level of Text Complexity:

CCSS.ELA-LITERACY.CCRA.R.10

Read and comprehend complex literary and informational texts independently and proficiently.

Text Types and Purposes[1]:

CCSS.ELA-LITERACY.CCRA.W.1

Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

CCSS.ELA-LITERACY.CCRA.W.2

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

CCSS.ELA-LITERACY.CCRA.W.3

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences.

Production and Distribution of Writing:

CCSS.ELA-LITERACY.CCRA.W.4

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CCSS.ELA-LITERACY.CCRA.W.5

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

CCSS.ELA-LITERACY.CCRA.W.6

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Research to Build and Present Knowledge:

CCSS.ELA-LITERACY.CCRA.W.7

Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

CCSS.ELA-LITERACY.CCRA.W.8

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

CCSS.ELA-LITERACY.CCRA.W.9

Draw evidence from literary or informational texts to support analysis, reflection, and research.

Range of Writing:

CCSS.ELA-LITERACY.CCRA.W.10

Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.