TESTING THE WINDMILLS

Performance Standards 12D/11B/13A/13B.I

Students will apply the concepts, principles and processes of historic technological design to investigate motion and pressure accordingly:

- *Knowledge:* understand Bernoulli's principles of flight and the relationship of structural elements associated with the generation of electricity from wind power.
- *Application:* apply technological design processes to design and test a historic propeller design in a wind-powered device.
- *Communication:* present and compare qualitative and quantitative findings from test of wind-powered propeller prototypes.

Procedures

1. ***In order to know and apply the concepts that describe force and motion and the principles that explain them (12D); the concepts, principles and processes of technological design (11B); the accepted practices of science (13A); and concepts that describe the interaction between science, technology and society (13B),*** students should experience sufficient learning experiences to develop the following:
   - Identify the historic settings for the new engineering solutions needed for wind-driven propellers for generation of electricity.
   - Brainstorm the circumstances and design components that were available in the identified historic settings.
   - Research the scientific (Bernoulli's Principle) and engineering principles (electric motor/generators, circuits, propellers) associated with 'lift,' circuitry, electrical generation, etc.
   - Identify the simulation materials and procedural sequence to replicate the historic setting.
   - Determine success criteria, design constraints, safety considerations and testing logistics for class investigations.
   - Sketch progressive schematics of the design components.
   - Determine and collect the appropriate prototype materials/supplies and testing/safety equipment.
   - Construct propeller and wind-driven electrical prototype.
   - Test prototype components through multiple trials, according to success criteria, scale and design constraints.
   - Collect reliable and precise data with available technologies.
   - Analyze data to evaluate design by comparing and summarizing data from multiple trials.
   - Evaluate conflicting data.
   - Correlate historic conditions and observations to the prototype testing.
   - Communicate design evaluation report.
   - Select graphs or charts that can display findings from investigation.
   - Relate historic setting and impact from engineering solution and the eventual progression of designs.
   - Associate the scientific and engineering concepts from this investigation to applicable career and occupational decisions.
   - Generate alternative design modifications which can be or could have been tested.

   Note to teacher: This activity relates to knowledge associated with Standard 12D, while addressing the Performance Descriptors for Stage I within Standard 11B. It integrates principles of safety and career applications as suggested in Standards 13A and B. Wind-powered generators have been used extensively in Europe to produce electricity during recent years and is gaining acceptance in the United States as an alternate source of electrical power. As the technology improves and the use of "wind mills" expands, there will be an increase in the number of industrial occupations related jobs available. Industrial occupations programs should incorporate the concept of wind power into their training as an example of potential future employment opportunities.
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Students should have a background in the basic operation of permanent magnet DC motors as generators (possibly Rowe Series 60D) and direct current circuitry. The investigation can begin with discussions about the historic settings for prairie generations for windmills and lead to discussions about modern wind farms. They should brainstorm the kinds of career and occupational settings and decisions that are associated with this

engineering innovation and solution. The investigation will center on the design, redesign and replication of the propellers used in wind-powered devices. Students should determine the criteria that should be used to evaluate prototype designs and the procedural constraints for the investigation. Students should secure drawings of historic designs and sketch a progressive sequence for construction and testing. Students should determine the materials and supplies needed to construct the selected design, as well as the necessary testing equipment and safety procedures and equipment. They should test their designs and collect appropriate data which can be used to evaluate the prototype's success. They should share their findings and compare design elements among classmates and to historic progression of design elements. Finally they should record conclusions and rationale about the best designs for wind-powered electric generation.

4. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   - *Knowledge*: The applications of Bernoulli's principle and the relationship of structural components associated with the generation of electricity from wind power were complete and correct.
   - *Application*: The technological design processes to construct and test the historic propeller design were thorough, well detailed and accurate.
   - *Communication*: The report was well organized, well detailed and complete.

Examples of Student Work

- Meets
- Exceeds

Time Requirements

- 1 - 2 class periods for explanation of expectations for investigation and propeller design options; 1 - 2 weeks for construction and testing of design; 2 - 3 days for presentations and design comparisons

Resources

- Science Rubric
- Motors, generators, circuitry equipment
- Testing equipment
- Propeller construction materials
- Access to research resources
- Internet sites such as http://www.otherpower.com/danb_windmill.html http://www.able-solar.co.nz/soma.htm http://www.windstreampower.com/windpower/windinfo.html

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Wind-powered generators have been used through history in locations around the world, especially in the Midwest in the 19th and 20th centuries. Some engineers predict that improvements to those designs can be used for 21st century generation of electricity.

You will design a propeller to match the load characteristics of a given DC Permanent Magnet Motor. Research the concept of load impedance of the generator and compare/match your propeller to this generator. Your design should be based on a 25 mph wind minimum and up to 40 mph wind capability.

HOWEVER---your design must use or simulate the materials, equipment, technology and knowledge available historically. Research the historical settings of 1800-1850, 1851-1900, 1901-1950, 1951-1970, or 1971-2000 to find the design constraints that existed during each time period.

What will be the success factors for the class' investigation? For example: How will you judge what works best? What kinds of materials will be allowed? How much time is to be allowed? How will the prototypes be tested? What factors will you test?

What safety factors need to be considered for both the classroom testing and in the historic setting?

Where can you find information?

What steps will you follow?

Sketch your initial and final design.

What career or occupational settings need or use these kinds of concepts, principles or processes?

How will you record your data? What kind of chart or table do you need?

Which design works the best? How do you know?

SCIENCE RUBRIC

Exceeds - must receive no more than one 3 and the rest 4s in the other areas of the rubric.
Meets - may receive no more than one 2 and a combination of 3s and 4s in the other areas of the rubric.
Approaches - may receive no more than one 1 and a combination of 2s, 3s or 4s, in the other areas of the rubric.
Begins - must receive at least a 1 in all 3 areas of the rubric.

	KNOWLEDGE Knows and understands scientific terms, facts, concepts, principles, theories and methods.	**APPLICATION** Applies scientific knowledge, skills and methods to manipulate, analyze, synthesize, create and evaluate.	**COMMUNICATION** Communicates scientific knowledge and applications through writing, speech and visual displays.
4	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are complete and correct.	• Applications are thorough, appropriate and accurate.	• Written, oral and/or visual communication is well organized and effective.
3	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are mostly complete and correct.	• Applications are mostly thorough, appropriate and accurate.	• Most of the written, oral and/or visual communication is well organized and effective.
2	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are somewhat complete and correct.	• Applications are somewhat appropriate and accurate.	• Some of the written, oral and/or visual communication is organized and effective.
1	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are minimally present or correct.	• Applications are minimally appropriate and accurate.	• Little of the written, oral and/or visual communication is organized and effective.
0	• All descriptions of scientific terms, facts, concepts, principles, theories and methods are missing and/or incorrect.	• All applications are missing and/or incorrect.	• All of the written, oral or visual communication is missing and/or lacks organization.
Score			