Air Vehicles and Power and Propulsion

http://www.inhabitat.com/wp-content/uploads/mbformulazero1.jpg

Next Generation Wind Racer

Grade Level(s): Target 4th grade

Academic Content Areas: Science, Technology, Engineering, and Mathematics

Topics: Earth & Space Sciences; Science &Technology; Scientific Inquiry; Scientific Ways of Knowing; Measurement; Patterns, Functions and Algebra; Data Analysis and Probability

Recommended Area of co-teaching with an AFRL Engineer or Scientist

Main Problem / Essential Question

As the benefits of green technology grow and the disadvantages to the US's dependence on fossil fuels become more obvious, we must consider how to change our consumer habits in support of green technology.

Student challenge is to design a wind powered land vehicle model. This design is to serve as a model for future designs of racers such as formula one cars. Students will need to figure out how to harness wind for propulsion and design a basic vehicle frame for experimentation.

Summary

Over the course of nine short lessons students will establish the benefits of a wind powered vehicle, explore the definition of a Formula One race car, compile materials suitable for this build, design a vehicle that can harness wind for propulsion, build a formula one wind racer, test their vehicle, redesign or modify based on initial test results, test their final vehicle design, and then conduct speed trials in which students will compete against peer designs. Both testing phases will require students to record, organize, and analyze their results. Students will cement their understanding in wind as a source of energy, build their understanding of benefits of current technology, explore science as doing and practice grade appropriate mathematical skills to address Ohio Academic Content Standards.

Big Ideas / Focus

Wind can be used as propulsion. Unlike oil or coal, wind is a renewable source of energy. Current technology uses wind turbines to create electricity without the pollution that fossil fuels create. Green technology is being applied in multiple fields of industry including vehicle design. Bio diesel, ethanol, and hydrogen engines boast greener vehicles by reducing emissions. Researchers are exploring multiple avenues of green technology for automobiles. Students will conduct their own research on harnessing wind energy to propel their own model race car. Students will need to understand how to use air, wind direction, basic building skills, scientific testing, and data collection as well as analysis to create their own team's Next Generation Wind Racer.

Prerequisite Knowledge

Students should be able to measure wind speed using an anemometer. (This will be done in lesson one. If students are not familiar with this tool and technique, allot more time to this lesson to accomplish this skill set.)

How to use MS Excel to create a graph:
http://www.internet4classrooms.com/excel_create_chart.htm

Standards Connections

Earth and Space Science Standard

Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

Grade 4 – Benchmark D: Analyze weather and changes that occur over a period of time.	1. Explain that air surrounds us, takes up space, moves around us as wind, and may be measured using barometric pressure. 4. Describe weather by measurable quantities such as temperature, wind direction, wind speed, precipitation and barometric pressure.

Science and Technology Standard

Students recognize that science and technology are interconnected and that using technology involves assessment of the benefits, risks and costs. Students should build scientific and technological knowledge, as well as the skill required to design and construct devices. In addition, they should develop the processes to solve problems and understand that problems may be solved in several ways.

Grade 4 – Benchmark A: Describe how technology affects human life.	2. Investigate how technology and inventions change to meet peoples' needs and wants.
Grade 4 – Benchmark B: Describe and illustrate the design process.	3. Describe, illustrate and evaluate the design process used to solve a problem.

Scientific Inquiry Standard
Students develop scientific habits of mind as they use the processes of scientific inquiry to ask valid questions and to gather and analyze information. They understand how to develop hypotheses and make predictions. They are able to reflect on scientific practices as they develop plans of action to create and evaluate a variety of conclusions. Students are also able to demonstrate the ability to communicate their findings to others.

Grade 4 – Benchmark A: Use appropriate instruments safely to observe, measure and collect data when conducting a scientific investigation.	1. Select the appropriate tools and use relevant safety procedures to measure and record length, weight, volume, temperature and area in metric and English units.
Grade 4 – Benchmark C: Develop, design and safely conduct scientific investigations and communicate the results.	3. Develop, design and conduct safe, simple investigations or experiments to answer questions. 4. Explain the importance of keeping conditions the same in an experiment. 5. Describe how comparisons may not be fair when some conditions are not kept the same between experiments. 6. Formulate instructions and communicate data in a manner that allows others to understand and repeat an investigation or experiment.

Scientific Ways of Knowing Standard
Students realize that the current body of scientific knowledge must be based on evidence, be predictive, logical, subject to modification and limited to the natural world. This includes demonstrating an understanding that scientific knowledge grows and advances as new evidence is discovered to support or modify existing theories, as well as to encourage the development of new theories. Students are able to reflect on ethical scientific practices and demonstrate an understanding of how the current body of scientific knowledge reflects the historical and cultural contributions of women and men who provide us with a more reliable and comprehensive understanding of the natural world.

Grade 4 – Benchmark C: Explain the importance of keeping records of observations and investigations that are accurate and understandable.	2. Record the results and data from an investigation and make a reasonable explanation.

Measurement Standard
Students estimate and measure to a required degree of accuracy and precision by selecting and using appropriate units, tools and technologies.

Grade 4 – Benchmark C: Develop common referents for units of measure for length, weight, volume (capacity) and time to make comparisons and estimates.	6. Write, solve and verify solutions to multi-step problems involving measurement.

Patterns and Functions and Algebra Standard
Students use patterns, relations and functions to model, represent and analyze problem situations that involve variable quantities. Students analyze, model and solve problems using various representations such as tables, graphs and equations.

Grade 4- Benchmark F: Construct and use a table of values to solve problems associated with mathematical relationships. Grade 4- Benchmark G: Describe how a change in one variable affects the value of a related variable.	6. Describe how a change in one variable affects the value of a related variable; e.g., as one increases the other increases or as one increases the other decreases.

Data Analysis and Probability Standard
Students pose questions and collect, organize, represent, interpret and analyze data to answer those questions. Students develop and evaluate inferences, predictions and arguments that are based on data.

Grade 4 – Benchmark A: Gather and organize data from surveys and classroom experiments, including data collected over a period of time. Grade 4 – Benchmark B. Read and interpret tables, charts, graphs (bar, picture, line, line plot), and timelines as sources of information, identify main idea, draw conclusions, and make predictions.	1. Create a plan for collecting data for a specific purpose. 2. Represent and interpret data using tables, bar graphs, line plots and line graphs. 5. Propose and explain interpretations and predictions based on data displayed in tables, charts and graphs.

Preparation for activity

Day 1: Pretest & Wind Inquiry & Wind Speed Measurement

- Copies of Pretest or use electronic version of pretest, electronic white board, and student response system.
- Setup Wind Inquiry Stations:
  - Setup stands and hair dryers in testing stations for students to explore wind and its ability to "do work".
  - Have piles of miscellaneous objects such as paper scraps, fabric scraps, string, matchbox cars, paper clips, etc. for students to experiment harnessing wind.
  - Place an anemometer at each station for student use and testing.

Day 2: Introduce lesson problem & Design of a Formula One Race Car: Students design their own Next Generation Wind Racer. Home work: Collect building materials.

- Determine student teams.

- Collect sample construction materials available for student's Next Generation Racer build.
- Gather a few pictures of Formula One race cars to share with students for brainstorming session.

Day 3: Build Next Generation Wind Racer Prototype

- Have building supplies available.
- Setup a wind station for testing needed during the build.

Day 4: Test Next Generation Wind Racer Prototype & Record results

- Have hair dryers and stands set up in an area that has a long distance (15ft) where vehicles can be tested.

Day 5: Analyze results & explore current wind powered vehicles such as the Mercedes Benz Formula zero race car

- Arrange access to Microsoft Excel for student's data analysis.

Day 6: Redesign

- Have extra building supplies available for student redesign.

Day 7: Test Next Generation Wind Racer & Record results

- Have hair dryers and stands set up in an area that has a race strip (15ft) where vehicles can be tested.
- Have pennies or metal washers available for payload testing.

Day 8: Speed trials for Next Generation Wind Racers

- Have hair dryers and stands set up in an area that has a race strip (15ft) where vehicles can be tested.
- Have pennies or metal washers available for payload testing.
- Set up electronic white board and Microsoft Excel for class data collection from speed trials.

Day 9: Post test

Critical Vocabulary

anemometer - *an instrument for measuring and indicating the force or speed of the wind*

propulsion – *a force causing movement*.

renewable energy - *energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are naturally replenished faster than which we can consume them.*

sail - *A piece of material fitted to a vessel so as to convert the force of the wind into movement of the vessel.*

wind - *a natural movement of air of any velocity*

wind speed- *the rate at which air moves.*

wind turbine - *a rotary device that extracts energy from the wind.*

Timeframe

Day	Time Allotment	Activities
1	60 minutes	Pretest & Wind Inquiry & Wind Speed Measurement
2	60 minutes	Introduce lesson problem & Design of a Formula One Race Car: Students design their own Next Generation Wind Racer Home work: Collect building materials
3	60 minutes	Build Next Generation Wind Racer Prototype
4	60 minutes	Test Next Generation Wind Racer Prototype & Record results
5	60 minutes	Analyze results & explore current wind powered vehicles such as: Mercedes Benz formula zero race car
6	60 minutes	Redesign
7	60 minutes	Test Next Generation Wind Racer & Record results
8	60 minutes	Speed trials for Next Generation Wind Racers
9	20 minutes	Post test

Materials & Equipment

Images of Formula one race cars

Scissors

Tape (masking, clear, etc.)

Putty/ clay (to be used as an adhesive)

4-6: Anemometers

4-6: Variable speed hair dryers (high and low settings)

4-6: Laboratory stands and clamps to hold the hair dryer

4-6: Stop watches

4-6: Tape measures or yard sticks

Paper for sails (8" X 10" copy paper or newspaper is recommended)

Straws

Large Index cards or other heavy weight paper for base

Small dowel rods (cut in 4-6in lengths for wheel chassis)

Plastic bottle lids or other wheel like objects

Pennies or small metal washers for weights

Supplies from home such as: straws, bottle lids, water bottles, small milk jugs, plastic lids, straws, strings, paper clips, fabric scraps, cardboard, etc.)

Miscellaneous objects such as paper scraps, fabric scraps, string, matchbox cars, paper clips, etc. (for day 1)

Glue gun/ glue*

Exacto blade/box cutter*

* Items are intended for teacher use only.

Safety & Disposal

Students should be cautioned about working safely near the hot hair dryers.

Students must be cautioned about using care with scissors and other supplies while assembling their vehicles.

If using a glue gun, students should be cautioned that glue is hot after application.

Pre-Activity Discussion

Discuss renewable energy or "going green" with students. (http://www.greenenergychoice.com/: webpage containing "green energy" information)

- Elicit any individual knowledge students may have about this energy movement including the causes and the potential effects this effort will have in our society.
- Discuss any current technology or trends students may be aware such as Flexfuel vehicles, using fabric bags instead of plastic, recycling, energy saving light bulbs, etc.

Ask students if they have ideas on how to design a vehicle that can be powered by wind? This vehicle prototype will need to successfully travel 30 ft across the across the classroom floor without tipping over.

Teacher Instructions

Students should use a science journal to record all experimental data.

Day 1: Pretest & Wind Inquiry & Wind Speed Measurement

- Administer Pretest (20 minutes)
- Discuss wind as a force of moving air molecules that can be measured with an anemometer. Discuss how wind is moving air and how weather affect air (creating temperature differences and change in wind). (10 minutes)
- Place students in 4-6 groups depending on number of hair dryers. (This will be the student grouping throughout the lesson, if desired these groups may be broken into two design teams.)
- Allow students to go to the Wind inquiry station, as setup in preparation day 1 section. (30 minutes)

  Post these goals for students:

  - Create a table in your science journal to record anemometer reading for variable speeds on the hair dryer and or fan.

- Hypothesize which setting created the most force.
- Explore wind, lift, and air movement using the miscellaneous materials provided. Record the affect of wind on at least 4 objects.

- Homework: In science journals, have students brainstorm on the relationship of weather, wind, and air. Have students write 5 sentences about the relationship of these words.

Example:
1. Wind is made up of moving air. 2. Different types weather have different types of wind. 3. Air can be hot and cold just like weather. 4. The weather in fall is cold and windy. 5. Summer weather has warm air.

Day 2: Introduce lesson problem & Design of a Formula One Race Car: Students design their own Next Generation Wind Racer. Home work: Collect building materials.

- Problem: Design a wind powered land vehicle model. This design is to serve as a model for future designs of racers such as formula one cars. Students will need to figure out how to harness wind for propulsion and design a basic vehicle frame for experimentation. The initial goal is to design a vehicle needs to successfully travel 15 ft without tipping over.
- Share pictures of current formula 1 race cars.
- Discuss the benefits of designing a "green" race car as being better for the planet by lowering pollution and lowering consumption of oil.
- Discuss students findings from Day 1 lab activities. Elicit what materials harnessed the wind best and speeds recorded for different settings on the fan/hair dryers. Discuss how students can apply this knowledge to their Next Generation Racer.
- Have students work in small groups to brainstorm their own Next Generation Racer. Remind students that they will have to build their model from common supplies such as water bottles, fabric scraps, etc.
- Post question on the board and have students provide a written answer in their science journals while working on their design.

  What design features will help to best propel their vehicle across a surface? *Answer should include wind harnessing mechanism and possibly reference weight and/or wheels.*
- Have students create a labeled diagram of their Next Generation Racer in their science journals.
- Home work: Collect building materials.

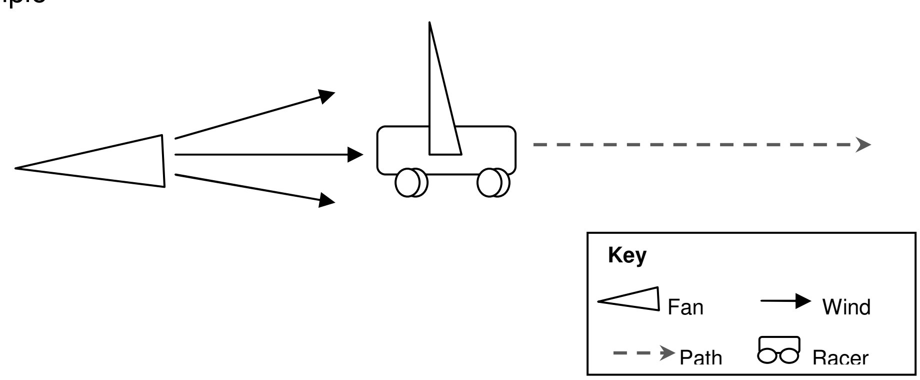
Day 3: Build Next Generation Wind Racer Prototype

- Provide students with building supplies in addition to any supplies they have brought from home.
- Have students refer to their design as they build. Discuss that if design modifications are necessary during the building process, students need to document these changes in their science journal.
- Allow students time to build their design.

Teachers Note: Having a wind station setup during this phase will allow students to test as they build. This may be conducive to solidifying the force of the wind and directionality of the wind harness on the vehicle.

- Have students draw a diagram in their science journal depicting what direction their vehicle needs to be facing in reference to the wind source. Have students use arrows to depict wind direction. Have students draw a path they expect their vehicle to take.

Example



Day 4: Test Next Generation Wind Racer Prototype & Record results

- Have teams take turns placing their vehicle in front of the hair dryer and test the wind's effectiveness to power/propel the vehicle at different wind speeds(high and low settings on the hair dryer). Have one student use the anemometer to record wind speed. Have another student use the stop watch to record the time the vehicle moves across the table (start when the vehicle starts moving, stop when the vehicle stops moving) use a yard stick or tape measure to record the distance traveled by the vehicle.
- Students should repeat the experiment at least three times at each wind speed (hair dryer) setting.

Teachers Note: Remind students to stop the stop watch as soon as the vehicle stops moving, since we are trying to calculate speed.

- All students are responsible for recording the data in their science journal.

Discuss what problems students faced including design flaws, measurement issues, etc. (10 min)

Day 5: Analyze results & explore current wind powered vehicles such as the Mercedes Benz Formula zero race car.

- Have students create a graph displaying time vs. distance from the data collected on Day 4, within excel. Have students calculate the average speed of their vehicle Have students place their excel spreadsheet and graph as well as their speed calculations in their science journal. (30 min).
- Explore some pictures of current Wind Vehicles such as Mercedes Formula Zero Racer, M6 Speedster, Ventomobile, and the Nemesis wind car. (30 min)

  Teachers Note: Use of an electronic whiteboard and the internet will allow students to lead internet inquiry on these concept vehicles and prototypes as well as allow students to connect the design challenge to "green" efforts.
- Homework: Have students write a paragraph in their science journals on how to improve their design. Have students bring in any desired extra supplies for day 6's redesign.

Day 6: Redesign

- Allow students to break up into their groups and discuss their redesign. Have students refer to their homework from lesson 5. (15 min)
- Allow students to modify their Next Generation Racers.
- Homework: Have students write a paragraph in their science journals on the importance of keeping variable and conditions the same in an experiment (the same hairdryer, the same speed on the hair dryer, and the same test track). Why wouldn't it be fair if each team had different settings on the hair dryer?

Day 7: Test Next Generation Wind Racer & Record results

- Discuss Day 6's homework answers.
- Have teams take turns placing their vehicle in front of the hair dryer and test their vehicle design on race strips.
- Students should test their vehicle on the hairdryer setting they think works best.
- Students should repeat the experiment at least three times at chosen wind speed.
- Students should repeat experiment with 10, 20, and 30 pennies (or metal washers). The experiment should be tested three times for each weight.
- Student should collect data in their science journals.

Example

Hair Dryer Setting: __High___

	Time	Distance
Empty Racer		
Empty Racer		
Empty Racer		
Racer with 10 Pennies		
Racer with 10 Pennies		
Racer with 10 Pennies		
Racer with 20 Pennies		
Racer with 20 Pennies		
Racer with 20 Pennies		
Racer with 30 Pennies		
Racer with 30 Pennies		
Racer with 30 Pennies		

Teachers Note: It is recommended that before starting this phase of testing. The class should actively decide on how to create a table to record all of the data. Display a mock table for students to "copy" into their science journal.

Day 8: Speed trials for Next Generation Wind Racers

- The class should determine the choice wind speed for the time trials. Individual teams should decide how many pennies to use based on their findings in Day 7 for ideal performance of their racer. Students should measure and tape off a specific race strip length, this should designated by a finish line (made from masking tape). (15 min)
- Each team should race their racer twice. Two classmates should be at the finish line and use stop watches to record racers speeds. This data should be placed in a Microsoft Excel spreadsheet on an electronic white board where all students can study and analyze the results as they are accumulated.
- After all data is collected discuss the best times and design ideas. Discuss what students have learned about wind as a renewable resource. Discuss what students have learned from their experimentation with different variables (e.g., size and position of "sail", weights, vehicle design etc. (15 minutes)
- Homework: Have students write a paragraph in their science journals about how their Next Generation Racer worked using air. Students should explain how they optimized their racer in their redesign.

Day 9: Post test

- Administer Post test (20 minutes)

Background Information

Current research efforts are underway by many independent companies in attempts to harness wind energy to do different work. Currently, wind turbine farms are in use and being assembled across the US in order to collect energy from wind. http://www.greenenergyohio.org/page.cfm?pageId=102 and http://www.greenenergyohio.org/page.cfm?pageID=104 discuss current wind turbine farms in Ohio.

In addition to traditional wind turbines, industrial efforts have been exploring the use of wind to propel a land vehicle. Although most research is in the conceptual phases a few prototypes are on the street today, such as the Nemesis. One of the main challenges these machines face is that wind is not a constant therefore one driving design plan is to have batteries that are charged by the wind energy and provide power when the wind is not suitable for transport.

Instructional tips

During wind inquiry, students may need to be provided with goals such as which objects “fly away” better, which objects “bend or give” to the wind, etc.

Remind students that their Racer will have to compete in a straight line race. Help students discover that placement of the sail portion of their vehicle will help with directionality.

An alternative to creating a graphical representation of student and class finding within Microsoft Excel is http://nces.ed.gov/nceskids/createagraph/.

Assignment of Student Roles and Responsibilities:

Students will all assume the same role:

Role Name	Brief Description
Mechanical Engineer	Responsible for performing experimental tests, manipulating equipment safely & properly, recording data, writing results and conclusions.

Student Instructions

Students are to follow instructions and science journal requirements, including the engineering, testing, modification, and speed trials that are provided by teacher and discussed within teacher instructions.

Formative Assessments

Use of the pre test and post test as well as science journal requirements provide feedback on student understanding an conceptual growth throughout the unit.

Post-Activity Discussion

- Which racer design worked best how do you know?
- Did the added weight affect the racers motion?
- Which modifications to your vehicle made the biggest difference? How do you know? Why do you think this?

Pre-Test / Post-Test

1. Does wind have enough power to move a large object such as a car or vehicle? Explain. *Answers will vary, possible answer: Yes the wind has enough power to move a massive object on windy days. I know because I can see the trees bend when it is windy. I can feel the power of the wind on windy days and observe how it can make objects move.*

2. Does the speed of wind matter when attempting to power a vehicle? Why or why not? *Yes wind speed matters when attempting to power a vehicle. If it is too slow and the boat will not sail. If the wind speed is too fast, the boat may tip over or the sail may be destroyed.*

3. How can weather affect a wind powered vehicle? *Weather creates wind so changes in weather will change the amount of wind available to propel the vehicle.*

4. How does the size and shape of a sail change the motion of a vehicle? Provide an example. *Answers will vary based on individual lab results, possible answer: The size of a sail can change the motion of a vehicle because if the sail is too small, it will not catch the wind. If it is too large, it will catch too much wind and fall over.*

5. Can wind power be harnessed and used as an alternative source of energy? How? *Yes, wind power can be harnessed and stored by using a windmill/wind turbine. The wind could be used to propel a vehicle.*

6. What tool measures air movement?

   a. thermometer

   b. anemometer

   c. wind speed

   d. fan

7. Wind energy is ___________________.

   a. renewable

   b. created by weather

   c. is harnessed by windmills

   d. all of the above

Pre-Test / Post-Test Rubric

CATEGORY	3	2	1
1. Does wind have enough power to move a large object such as a car or vehicle? Explain.	Answers yes. Explains by providing a specific observation such as bending trees, tornados, etc.	Answers yes. Provides inaccurate explanation.	Answers Yes. Does not attempt to provide explanation.
2. Does the speed of wind matter when attempting to power a vehicle? Why or why not?	Answers yes. Explains that when wind speed is too slow, the vehicle will not move. When wind speed is too fast, it can tip the vehicle over or make unstable.	Answers yes. Does not accurately explain that when wind speed is too slow, the vehicle will not move. When wind speed is too fast, it can tip the vehicle over or make unstable.	Answers Yes. Does not attempt to provide explanation.
3. How can weather affect a wind powered vehicle?	Response indicates a clear understanding that weather causes wind and a wind powered vehicle relies on this source of propulsion. (e.g. weather = wind = propulsion for a wind powered vehicle)	Response explains that weather (or changes in weather) creates wind but does not connect the affects of the wind to the wind powered vehicle. (e.g. weather = wind)	Response provides examples such as speed of vehicle or stability of vehicle dependant on the amount of wind available. (e.g. wind= result on wind powered vehicle)
4. How does the size and shape of a sail change the motion of a vehicle? Provide an example.	Response indicates that the size of a sail can change the motion of a vehicle. Example is provided: If the sail is too small, it will not catch the wind. If it is too large, it will catch too much wind and fall over.	Response indicates that the size of a sail can change the motion of a vehicle. Example is that it will either catch too little or too much wind.	Response indicates that the size of a sail can change the motion of a vehicle.
5. Can wind power be harnessed and used as an alternative source of energy? How?	Answers yes. States that wind power can be harnessed/ stored and or used by; turning blades to charge batteries/ collect electricity, using wind power to turn a wind mill, using wind power to propel a vehicle. (Yes + example & explanation)	Answers yes. States either that wind power can be harnessed/ stored and or used by wind mill, wind turbine, or wind propelled vehicle. (Yes + example)	Answers yes. OR Provides example.

6. What tool measures air movement?		Circles B. Anemometer	
7. Wind energy is _____.		Circles D. All of the above	

Technology Connection

The **ADISC** Model of technology created by ITEL:

Integration Model	Application Description
Technology that supports students and teachers in **adjusting, adapting, or augmenting** teaching and learning to meet the needs of individual learners or groups of learners	http://nces.ed.gov/nceskids/createagraph/
Technology that supports students and teachers in **dealing effectively with data**, including data management, manipulation, and display	Electronic White Board Microsoft Excel
Technology that supports students and teachers in conducting **inquiry**, including the effective use of Internet research methods	Electronic White Board Internet Anemometer
Technology that supports students and teachers in **communicating and collaborating** including the effective use of multimedia tools and online collaboration	Microsoft Excel http://nces.ed.gov/nceskids/createagraph/

Interdisciplinary Connection

This activity can be integrated with Art, Math, Social Studies, and Language Arts.

- **Art** to draw and design the sails.
- **Social Studies** for understanding how wind was used by past civilizations.
- **Language Arts** to write and describe the steps to the design process, persuade more people to use wind power, or explore more renewable energy types and their uses.

Home Connection

Send design specifications home with the students and challenge families to build their own next generation racer then host a race night at the school where home racers compete along with classroom racers.

Differentiated Instruction

Product: Some students may need help with ideas/construction for sails. Some sails can be pre-made for student use to encourage students to continue with the design process.

Content: More advanced students can be expected/challenged to design a boat that not only sails, but must also carry or haul a payload.

Extensions

This lesson can be connected to other mechanisms that rely on wind energy such as kites, windmills, wind turbines, or sailboats.

This lesson can be connected to Earth day or studying other forms of renewable energy.

This lesson can be continued into a math lesson where students can find area and perimeter of their bases and sails. Then compare measurements with other teams in order to decide if these measurements play a role in a better boat design.

Career Connection

There is a whole field of research in harnessing the wind as a source of renewable energy. Engineers and physicists who study and design wind turbines are concerned with turbine efficiency and design as well as energy storage and proper placement of wind turbines on wind farms, in order to maximize energy collection. Below is a link to a short (less than 6 minutes) movie about a wind farm:
http://www.thefutureschannel.com/dockets/science_technology/wind_farming/

Current research efforts between the Air Force and Defense Advanced Research Projects Agency (DARPA) are exploring wind speeds at different altitudes in order to best design a propulsion system for stratospheric airships, ISIS program, that are being designed to hover at varying altitudes to collect surveillance information. Since winds are affected by weather systems, scientists are better trying to understand atmospheric weather patterns in order to determine the best propulsion design suitable for this airship.

Additional Resources

Additional Resources	*Purpose and Application*
http://www.thefutureschannel.com/dockets/algebra/windsails/index.php	A short (less than 2 minutes) movie about designing a wind sail for a surfboard that can skim the surface of the sea at 20 miles per hour and still respond instantly to the touch of the sailor.
http://www.thefutureschannel.com/dockets/science_technology/wind_farming/	The Futures Channel – The Wind Business
http://www.greenenergyohio.org/page.cfm?pageId=102	Six Wind Turbines at the Dull Homestead in Brookville Ohio

http://www.greenenergyohio.org/page.cfm?pageID=104	Ohio's First Commercial Wind Farm
http://www.youtube.com/watch?v=B7h6ZGOsa-Y	Wind race of two wind powered vehicles, the Aeolus and the Ventomobile.

Credits

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Teacher Reflections

- Were students focused and on task throughout the lesson? *Insert answer here.*
- If not, what improvements could be made the next time this lesson is used? *Insert answer here.*
- Were the students led too much in the lesson or did they need more guidance? *Insert answer here.*
- Did the students learn what they were supposed to learn? *Insert answer here.*
- How do you know? *Insert answer here.*
- How did students demonstrate that they were actively learning? *Insert answer here.*
- Did you find it necessary to make any adjustments during the lesson? *Insert answer here.*
- What were they? *Insert answer here.*
- Did the materials that the students were using affect classroom behavior or management? *Insert answer here.*
- What were some of the problems students encountered when using the …? *Insert answer here.*
- Are there better items that can be used next time? *Insert answer here.*
- Which ones worked particularly well? *Insert answer here.*

Additional Comments

Name ________________________________

Test

1. Does wind have enough power to move a large object such as a car or vehicle? Explain.

2. Does the speed of wind matter when attempting to power a vehicle? Why or why not?

3. How can weather affect a wind powered vehicle?

4. How does the size and shape of a sail change the motion of a vehicle? Provide an example.

5. Can wind power be harnessed and used as an alternative source of energy? How?

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6. What tool measures air movement?

a. thermometer

b. anemometer

c. wind speed

d. fan

7. Wind energy ___________________.

a. renewable

b. created by weather

c. is harnessed by windmills

d. all of the above