Wind Turbines: Structures and Forces

WIND TURBINE TECHNICIAN, ELECTRICIAN, POWERLINE TECHNICIAN

GRADES	LEARNING OBJECTIVE	CONCEPTS
Grade 7	Students will use the engineering design process to design, build, test, and improve wind turbine blades that efficiently transform wind energy into electrical energy. They will explore how structure, material, surface area, and blade angle affect performance.	• Construction materials • Strength and Stability • Forces • Engineering Design Process • Renewable energy • Generation of electricity • Aerodynamics • Surface area Angles

Curriculum connections

GRADE 7 SCIENCE

- Describe and interpret different types of structures encountered in everyday objects, buildings, plants and animals; and identify materials from which they are made
    - describe and compare example structures developed by different cultures and at different times; and interpret differences in functions, materials and aesthetics
    - identify points of failure and modes of failure in natural and built structures

- Investigate and analyze forces within structures, and forces applied to them
    - identify tension, compression, shearing and bending forces within a structure; and describe how these forces can cause the structure to fail
    - analyze a design, and identify properties of materials that are important to individual parts of the structure

- Investigate and analyze the properties of materials used in structures
    - devise and use methods of testing the strength and flexibility of materials used in a structure
    - identify points in a structure where flexible or fixed joints are required, and evaluate the appropriateness of different types of joints for the particular application
    - compare structural properties of different materials, including natural materials and synthetics

Description

Using the wind turbine kit, students will examine the viability of wind as an energy source. Students will construct wind turbines and engage in the engineering design process to design, construct, and test their wind turbine blades. Using concepts such as blade length, shape, material, and angles, students will harness the wind to produce electricity.

Wind turbine technicians work with this renewable energy source daily. Wind turbine technicians construct and maintain turbines as well as repair turbine blades. They focus on everything electrical and mechanical within the wind turbine. Powerline Technicians ensure that the electricity generated from wind turbines is transported from the wind turbine to its destination. Powerline technicians maintain powerlines and transformers. Electricians work with electricity and circuitry and are the professionals who work within a building such as a residence or commercial building.

TIME

- 90–120 minutes if students are designing their own blades.
- To complete this task in a shorter amount of time students can work in groups.

MATERIALS

- Vernier wind turbine kit (hub, ¼" dowels, Vernier power output module, generator, protractor)
- Fans
- Blades: cardboard, Balsa wood or lightweight foamboard or polypropylene (display board material)
- Scissors or utility blade
- Measuring tape or ruler
- Hot glue gun
- Phillips screwdriver

Procedure

PREPARATION

The project kit comes with three Vernier wind turbines. Educators can preassemble each turbine prior to the activity, if desired. This will cut down on the total time required to complete the project.

- Prior to this activity, students should have already learned about renewable and non-renewable energy sources such as fossil fuels, water and hydro, wind, and biomass.

If needed, assemble the Vernier wind turbine as outlined in the instructional video. Students can assemble their own wind turbines or educators can have them preassembled.

***NOTE: This full assembly is a ONE-TIME process.

STEPS

1. Once the kit is assembled, students can begin designing their three turbine blades. All three blades must be identical. During this design phase, teachers can prompt students to consider:
    - Forces on the Blades
        - How wind creates lift and drag.
        - How an unbalanced force makes the turbine spin.
        - Why some blade designs capture more wind than others.
    - Materials & Structure
        - How different materials resist bending or twisting.
        - The impact of weight and surface area on rotation.
        - Simple ways to reinforce blades for stability.
    - Design Factors
        - Blade length: short = fast spin, long = more torque.
        - Blade shape and how it affects aerodynamics.
        - Dowel placement and balance of the rotor.
        - Blade pitch (angle) and how changing it affects performance.

2. Once students have designed their blades, they will use the hot glue guns to secure their blades to the wood dowls. Once dried, they can insert their blades into the hub and attach the hub to the turbine by tightening the set screw with the Phillips screwdriver. NOTE: Students might need assistance opening the hub. This can be done by loosening the wing nut and using a dowel as a lever to pry open the hub. Students may need assistance when tightening the set screw.

3. Students will then generate wind by turning on the fan. Students will measure the effectiveness of their wind turbine by examining the volt reading on the Vernier power output module.

4. Students are encouraged to track the success of each blade design, including the blade pitch. Students can record their data in a table or chart or in a logbook. Using the collected data, students should adjust or modify their blade design through the redesign and retest phase of the engineering design process.

Assessment suggestions

PERFORMANCE TASK

Examine the effectiveness of each student's blade. Did the blade design enable the turbine to generate electricity from wind? Did the students engage in the engineering design process in an attempt to make improvements? This can be assessed using a rubric or checklist.

WRITTEN ASSESSMENT

Students can keep a written record of each blade test in a table or chart. Progress can be examined with each iteration. Students can then summarize what they learned from this activity.

COLLABORATION AND GROUP DISCUSSION

Students can take part in a group build where they engage in the engineering design process as a group. Students must collaborate with other group members when making decisions.

Extension

- Examine the effect of adding more blades to the hubs
- Additional blade materials can be examined
- Students can use the anemometer to determine optimal wind speed for their turbine
- Students can install the weights and turn their wind turbines into a windmill and lift weights.

Web resources

- Vernier turbine assembly video: KidWind Wind Turbine Assembly
- Vernier energy sensor software video: Investigate Renewable Energy Systems with Go Direct® Energy
- Link to free software: Vernier Canada Graphical Analysis

- STEM Video Resources: Wind Turbine Kit
- Scientific Method Worksheet: Wind Turbine Activity

Contributors

Warren Anderson, Joëlle Lavergne, Matthew Prete, Vernier Canada