What is the best design for a wind turbine?

The objective

In this experiment students will work in groups to design a model of a wind turbine that can lift a cup full of pennies or masses off the floor using the power of a hair dryer.

Introducing the experiment

Have students make a list of all the ways they have used electricity so far today. Ask them where that electricity comes from and how their day would have been different if they hadn't had access to electricity.

Show images of wind turbines and discuss what these are used for, where they have seen them. Explain that people who live in remote areas may not be connected to the power grid, or that connection may not be stable or consistent. What challenges would these people face in their day-to-day lives?

During the experiment

Helpful hints

Divide groups into 4 or 5, hand out the pupil sheet and discuss the variables that will be involved in making design decisions, such as:

- shape of the blades;
- size of the blades;
- thickness of the blades;
- number of blades; and
- how the shaft is attached to the desk.

For example, turbines that harness wind power to drive machinery, such as water pumps and windmills, need a higher torque and need to be more stable. They generally have a higher number of larger blades.

Discuss how the design could be made in as sustainable a way as possible, eg:

- by reusing scrap material rather than new;
- by reducing waste to a minimum (card, sellotape, string); or
- removing the need for a hairdryer.

SAFETY PRECAUTIONS

If students are going to use craft knives, make sure you demonstrate how to use them safely. You may find the following website on the safe use of craft knives helpful: **technologystudent.com/health1/safeagain2.html**

Discussion points after the experiment

When completing the wind power challenge, students can calculate the power of their wind turbine (this will be very small) using the equation:

$$\text{power} = \frac{mgh / t}{t}$$

Where m is the mass raised in kg (recommend using 5g masses i.e. 0.005kg), g is always 9.8N/kg and h is the height lifted in meters (not cm). They should measure the time in seconds using a stopwatch.

The energy transfers they discuss may include: electrical energy being transferred to the motor of the hairdryer, which transfers the energy to a kinetic energy (the moving blades, which transfer the energy to the moving air). The moving air is a kinetic energy store, which transfers energy to the blades of the turbine. These blades rotate (a store of kinetic energy) and transfer energy to the shaft, which rotates and winds up the string. As the cup rises, it is a store of kinetic energy. The heavier it is and the further it gets above the ground, the more gravitational potential energy the load has.

Give each group 2 minutes to explain their design, present their findings, and say how they would improve their design.

Useful information for this experiment

Wind turbines have been used for many years to grind wheat or pump water, but they can also be used to generate electricity. Modern wind turbines work by transferring the kinetic energy stored in wind to rotational energy of a rotor. This rotor is connected to a generator which turns and generates electricity. This electricity can be stored in a battery for use when the turbine is not being used or when there isn't enough wind.

People living in remote areas such as the Andes mountains in Peru or the Himalayas in Nepal often do not have access to the national power grid and have to rely on other sources like candles, kerosene and dry batteries for their energy needs. Wind turbines can provide the electricity to light homes and schools and allow people in remote areas to charge phone batteries and computers for communication and access to information.

For more school experiments and to access the accompanying videos, visit **royalsociety.org/schoolexperiments**

THANKS

This activity is based on an original resource, called *The Wind Power Challenge* designed by Practical Action for a British Science Association CREST award, who have kindly agreed to its use in the Royal Society Brian Cox School Experiments.

What is the best design for a wind turbine?

Your task is to design a model of a wind turbine that can lift a cup full of pennies or masses off the floor using the power of a hair dryer or fan.

Instructions

1. In your group, come up with two designs for your wind turbine.
   Design rules:
   - You must fix your wind turbine to the desk.
   - When operating your model, you must not touch it.
2. Decide which design you are going to use and why.
3. Construct your model and test it works.

EQUIPMENT LIST

- Hair dryer
- Cup
- Pennies or masses
- Stopwatch.

SAFETY PRECAUTIONS

- Make sure to use care when cutting with scissors or a craft knife.

Questions

1. How much mass did your wind turbine lift?

2. How much time did it take to lift?

3. Do you think it worked well? Why or why not

4. What would you like to change in your final model?

5. What will you do differently next time you do a challenge like this?

Extension

Power is measured in watts (W), and it measures the amount of energy transferred over time (1 W = 1 J/s).

To find the power of your wind turbine, use the equation:

$$\text{power} = \frac{mgh / t}{t}$$

Where:
m = mass (kg);
g = gravitational field strength (9.8N / kg);
h = the height the mass is lifted (in m); and
t = time taken to lift (in seconds)

1. How much power does your wind turbine generate?

2. You may have learnt already about energy transfers. Using your wind turbine as an example, describe the energy transfers that are taking place.

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What is the best design for a wind turbine?

Background

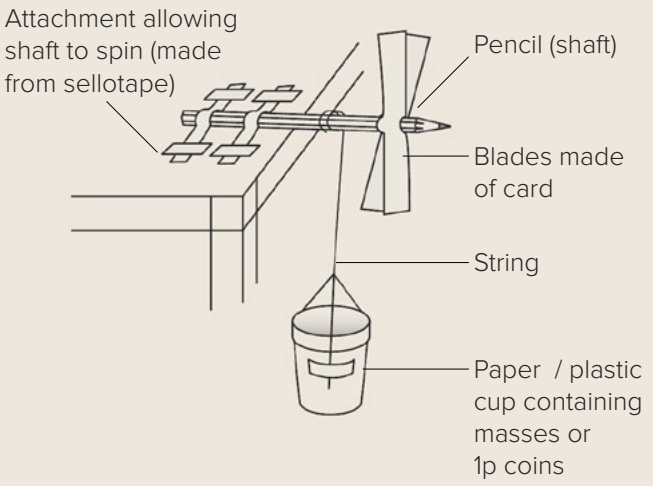
Students will work in groups to design a model of a wind turbine that can lift a cup full of pennies or masses off the floor using the power of a hair dryer.

Preparation notes

- Students will need to attach the wind turbine model to the desk. If the activity is going to require construction over more than 1 lesson, have the students attach them to cardboard or another sturdy surface that can be clamped to the desk so that they can be moved when the room is used for other lessons.
- The turbine they design is not very powerful, so using small masses is best.

For your eyes only

Do not show students the diagram, below, as they will be tempted to copy it and they should design it themselves.



Watch the accompanying classroom video to see this experiment being demonstrated and carried out with a class.

EQUIPMENT LIST

Students need a range of appropriate modelling materials and equipment for the challenge to make blades of different shapes and sizes, to stick everything together, and to attach their turbine to the desk.

Materials for each group

Modelling equipment suggestions

Card, straws, paper, cotton reels, dowelling, cocktail sticks, wooden skewers, pencils.

Joining and cutting equipment suggestions

Plasticine, string, Sellotape, masking tape, elastic bands, Blu-tack, scissors, glue, split pins, craft knives, paperclips.

Testing equipment

- Hairdryer or fan
- A paper or plastic cup
- Pennies or 5g masses
- Stop clock.

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