



Windmill

Design and technology

- Using mechanisms – gearing up and down
- Designing and making
- Combining materials
- Ratchets
- Safety and control systems

Science

- Forces and motion
- Renewable energy
- Measuring weight
- Measuring time
- Force
- Area
- Fair testing
- Energy capture, storage and use
- Scientific investigations

Vocabulary

- Renewable energy
- Force
- Area
- Weight
- Angle
- Shape
- Gearing down
- Efficiency

Other materials required

- Wind or desk fan
- Brass weights or playdough
- Stopwatch or other form of timer with a second hand
- Optional: card and scissors to make own sails for the Windmill

Connect

Jack and Jill have found a huge, but heavy treasure chest buried near an old mine. It is really heavy and though they try as hard as they can, they can't pull it out of the hole.

The old Windmill just nearby once used to lift water out of the mine and they are wondering if it can be of any help to them.

Zog the Dog has done a very good job helping them to dig out the treasure chest so he is pretty tired too. He walks away from Jack and Jill to rest a bit and suddenly finds a long piece of rope. He runs back to the two kids to suggest that they take him for a walk on his new "lead".

Jack has once seen a film where a mill was used to lift up something and seeing the rope he immediately tells Jill about his idea. Now they know they can figure out how to get the treasure out of the hole!

**How can you use a Windmill and a rope to lift a heavy load?
Let's find out!**



Construct

Build the Windmill

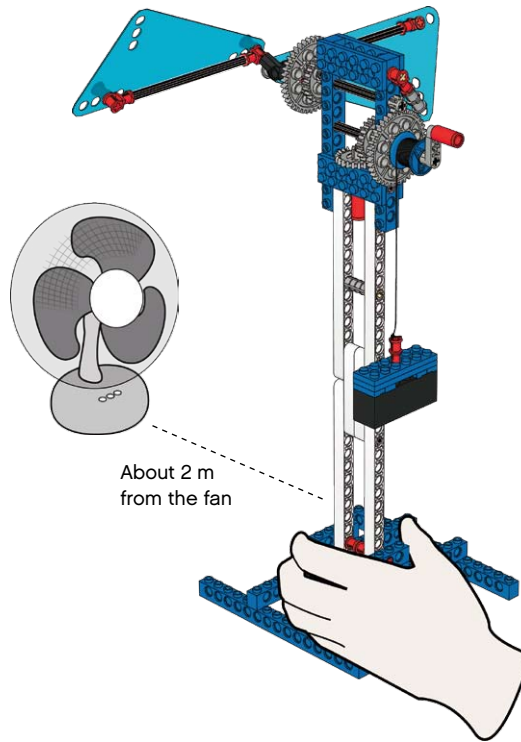
(all of book 8A and book 8B to page 12, step 17).

- Spin the mill by hand. Is it running smoothly?
- If it feels stiff to turn, loosen the axle bushings and make sure all other elements fit tightly together

Setting up the Windmill

NB. You will need to build one basic model in the start-up phase to help set up the test zone.

- Position the fan on the floor near a power outlet
- Place the model about 2 m away
- Choose a power setting, and move the model back and forth to find a distance where the wind speed is JUST SUFFICIENT to lift the weight brick, slowly
- KEEP THIS POWER SETTING FOR ALL TESTS (until you want to test the effect of different wind speeds, of course)
- Make a long line (e.g. with tape) in front of the Windmill. This is the test zone (where it is safe), and behind the line several groups can test several mills at the same time. Check that all the Windmills are subject to the same amount of wind



Contemplate

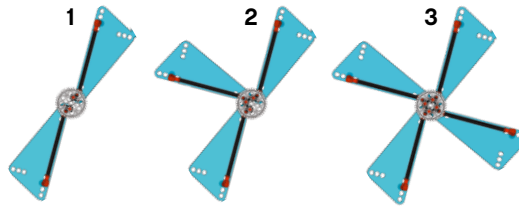
What is the best number of sails to use?

Predict and test which combination will lift up the treasure chest (weight brick) most quickly. Can you explain why?

Example 3 is best. It has the most area in which to catch the wind energy.

Surprise!

Example 2 with the sails off-centre is usually the worst. It is too unbalanced to work efficiently even though it has more area than Example 1 with just two sails.



Idea:

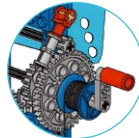
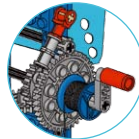
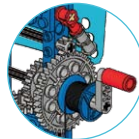
Does shape matter? If you have time, try making sails of different shaped pieces of card, but with the same area as that used in your models.

NB.

Each sail has an area of approx. 40 cm².

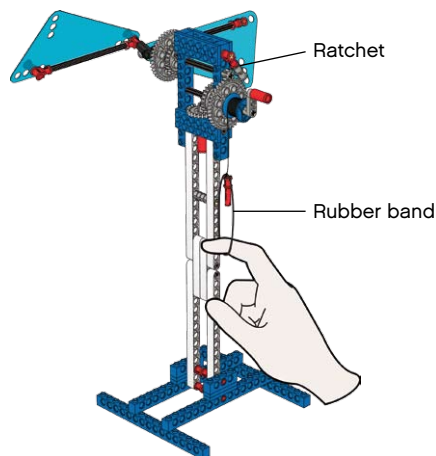
What does the ratchet do when:

- The load is being lifted up and the wind stops?
The mill stops but the ratchet stops the heavy load from falling. A good safety feature.
- The wind is blowing and you flip the ratchet to this position?
The mill stalls. The 'forces are opposite.'
- The load is up, the wind stops, and you flip the ratchet to this position?
It will become a fan powered by the energy stored in the falling load. You get the wind back again!



Rubber Band Force Meter

Tie a rubber band to the lifting string or use a spring balance to measure the lifting force before the mill stalls. Measure how much it stretches. You'll be amazed by the power generated!



Continue

In a Spin!

How can we store and use energy later?

In this exercise we are actually cranking the weight up by hand. You can do it using wind power too of course, if you then take off the sails before releasing the spinner.

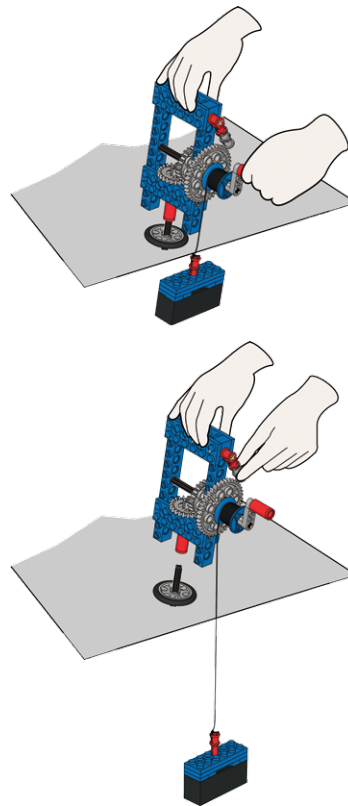
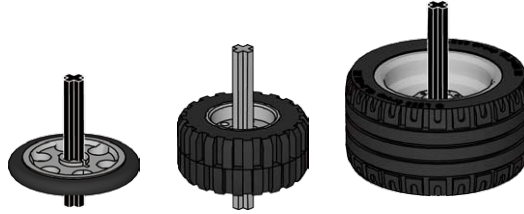
Disconnect the gearbox as in page 14, step 1 and make the 3 different spinning tops on pages 14, 15 and 16.

- Crank up the weight (adding energy) and flip the ratchet to hold the weight up (store the energy)
- Connect a spinning top
- Position the weight so it will fall over the edge of a table
- Flip the ratchet to release the energy in the weight brick so it spins the top
- Lift to release the spinning top
- This takes skill so be patient
- Which top will spin the longest and why? Predict and test more times with each spinner

More Spins

Invent your own spinners to see if you can get even more speed and longer spinning times.

Invent your own spinning games and introduce your very own scoring system.



Did you know?

The different spinning tops weigh approx.:

- 2 g
- 8 g
- 16 g