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| **Hero Engine** |
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| A project to make a water powered ‘hero’ rotary engine |
| **Subject(s):** Science, Engineering**Approx time:** 40 - 80 minutes |  | **Key words / Topics:** * force
* motion
* energy
* power
* rotation
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| **Stay safe** Whether you are a scientist researching a new medicine or an engineer solving climate change, safety always comes first. An adult must always be around and supervising when doing this activity. You are responsible for:• ensuring that any equipment used for this activity is in good working condition• behaving sensibly and following any safety instructions so as not to hurt or injure yourself or others Please note that in the absence of any negligence or other breach of duty by us, this activity is carried out at your own risk. It is important to take extra care at the stages marked with this symbol: ⚠ |
| **Suggested Learning Outcomes**  |  |  |
| * Know that every force produces an equal and opposite force (Newton’s third law of motion)
* Be able to make a working water powered hero rotary engine
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| **Introduction** |  |  |
| This is one of a series of resources designed to allow learners to use the theme of the future of flight to develop their knowledge and skills in Engineering and Science. This resource focusses on a water-powered ‘hero’ rotary engine, which converts water pressure to rotary motion. Devices of this type, called aeolipiles, were described by the mathematician Hero of Alexandria around 2100 years ago. These operated on the same principle but used water that was heated to make steam, rather than just water pressure. This activity introduces the concept of force and motion and energy transfer through the making of a rotary water-powered hero engine.  |
| **Purpose of this activity**In this activity learners will build a water-powered hero rotary engine. They will learn about force and motion using water power to create a simple rotary engine.This activity could be used as a main lesson activity, to teach learners about energy and Newton’s third law of motion contributing to learning in maths and science. Additionally, this could be used to start a discussion on other forms of energy and what factors affect flight. |
| **Activity** |  | **Teacher notes** |
| **Introduction (5-10 minutes)**Teacher to ask the class: why the blades of a helicopter need to go round? How do we make them (or a propeller) go round?Teacher to introduce the activity, to make a water-powered hero rotary engine.**Making the hero rotary engine** **(10-20 minutes)**Teacher to demonstrate the steps shown in the teacher presentation and listed below:* Step 1 – Make two holes on opposite sides on the base of the plastic bottle. ⚠
* Step 2 – Cut two 30 mm lengths of drinking straw. Cut one end of each straw at a 45 degree angle ⚠
* Step 3 – Push the straws into the holes. The end with the angle cut should be outside the bottle. Roll a small snake of sticky tack and place around each hole and press in firmly.
* Step 4 – Position the straws at an angle using the sticky tack to keep them in place.
* Step 5 – Make two holes on opposite sides on the bottleneck. Attach the string (or thread) through the holes and tie in a knot to make a loop.⚠
* Step 6 – Fill the bottle with water. Holding the string loop and see the water-powered hero engine spin!

**Performing the Activity (20-40 mins)**Learners to carry out making and testing their own hero engines.**Plenary (5-10 minutes)**Learners to share their experiences about building and running the hero engine. Did the hero engine work? How fast did it go? How could you control the speed of rotation? |  | This activity requires an area appropriate for working with water. Learners may also require aprons, towels etc.For the introduction, wind turbines could be used as a contrast – here the blades are moved by air to turn a generator, whereas in the helicopter the blades move the air to lift the aircraft.Learners may work in pairs or small groups to make the water powered hero rotary engine.Step 1 – The holes should be just large enough for the straw to fit through. The holes could be made using a bradawl or skewer. ⚠Step 3 – The straws should be parallel to the base and top of the bottle and at an angle of 45o to the plane of the hole. It is important the at the learners make sure the sticky tack is fully pressed around the straws to prevent leaks.Step 4 - The straws must point in opposite directions to each other to ensure that the bottle rotates (if they point in the same direction they will oppose the motion the other causes).Step 5 – The holes could be made using a bradawl, skewer or large needle. ⚠ Alternatively the string could be tied around the bottle neck if it is shaped appropriately to prevent slippage.Step 6 – Teacher may arrange an area either at a classroom sink or outside to fill the bottles with water. They may wish to use a bowl of water and a measuring jug to keep topping up the bottle. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * Provide learners with pre-pierced plastic bottles with string attached.
 |  | * Mark a line on one side of the bottle and count the number of times the bottle rotates in a set time. Use this to work out the speed (revolutions per minute, rpm). What can be modified to change the speed? How much do these changes alter the speed?
* Watch video YouTube: Newton’s third law of motion: <https://www.youtube.com/watch?v=a-wh3fJRdjo>
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Empty plastic one litre bottles
* String or thread
* Sticky tack
* Drinking straws
* Felt tipped pens
* Scissors
* Rulers
* Sharp point, such as a bradawl, large needle or metal skewer
* Stopwatch (for extension activity).
 |  | icon-ppt Presentation – Hero engine  |
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| **Additional websites** |
| * **YouTube**: Newton’s third law of motion: <https://www.youtube.com/watch?v=a-wh3fJRdjo>
* **Wikipedia:** History of Aeolipile engines: https://en.wikipedia.org/wiki/Aeolipile
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * Ask the class how many uses of water they can think of?
* Ask the class: why the blades of a helicopter need to go round? How do we make them (or a propeller) go round?
 | **Plenary*** Learners to share their experiences about building and running the hero engine. Did the hero engine work? How fast did it go? How could you control the speed of rotation?
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| **The Engineering Context** film |
| * Water engineers are responsible for the operation and maintenance of water-powered equipment. For example, hydro-electric engineers will use water to power turbines in dams to create electricity.
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| **Curriculum links** |
| **England: National Curriculum**KS2 ScienceEnergy changes and transfers* other processes that involve energy transfer: changing motion
 | **Northern Ireland Curriculum**KS2The world around us* the causes and effect of energy, forces and movement;
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| **Scotland: Curriculum for Excellence**KS2 ScienceForces, electricity and wavesSCN 4-07b* explains the motion of objects in situations involving constant acceleration.
 | **Wales: National Curriculum** KS2 ScienceHow things work* how familiar devices/machines work by using electricity, light, sound and other energy transfers
* the forces in devices and their relationship to work done and power
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| **Assessment opportunities** |
| * Informal formative assessment of the activity by the teacher.
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