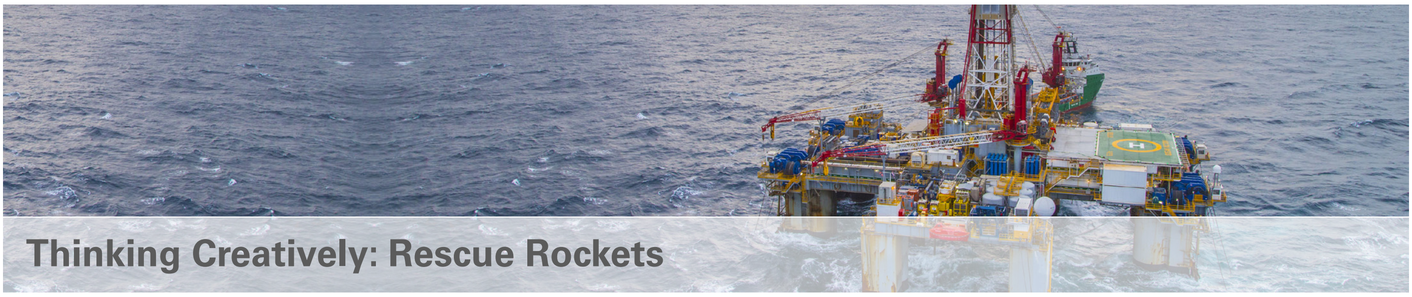
The Ultimate STEM Challenge

Brought to you by BP, the Science Museum and STEM Learning



Thinking Creatively: Rescue Rockets

BP operates oil rigs and ships around the world, often in remote places. While emergencies are rare, distress rockets or flares offer a visual signal that can be seen from many miles away. However, rocket propellants are not always good for the environment.

Do an investigation to find the most efficient design for a water-powered rocket.

You may wish to use these delivery notes to introduce the **Rescue Rockets** challenge and get your students started as they research and plan their ideas, design and build their model water rockets and complete an investigation to test their performance.

However, you and your students may wish to approach the challenge in an entirely different way.

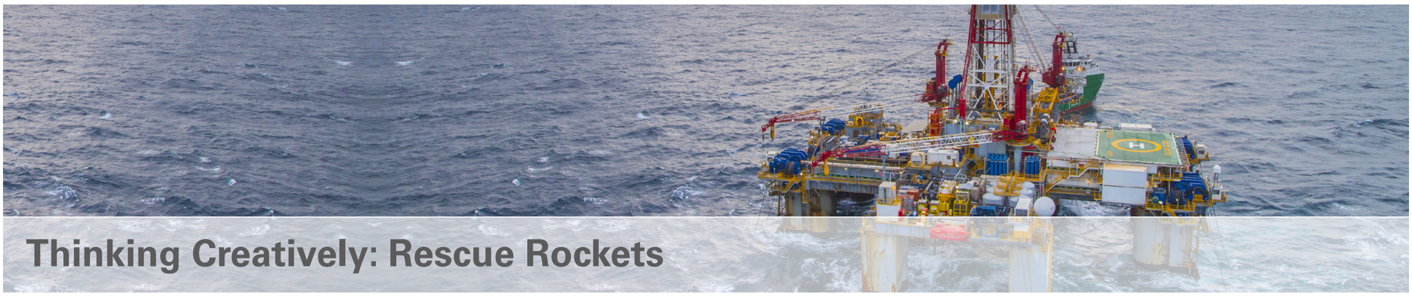
Getting started

- You can decide whether to choose which challenge your students will tackle, or whether to allow them to choose for themselves.
- This kick-off lesson would work well for STEM clubs, collapsed timetable days or a classroom lesson.
- Alternatively, you could run this introductory lesson and then encourage students to continue their projects on their own time, or as homework.
- It is up to you and your students how far you take the challenge and how many hours you dedicate to it.

Introducing the Ultimate STEM Challenge (PowerPoint presentation)

The PowerPoint can be used to introduce the Ultimate STEM Challenge. If you decide to choose which challenge your students will tackle, you can delete the slides relating to the others.

See the **Notes** bar at the bottom of each PowerPoint slide for more information and discussion prompts.



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Teacher support

After this kick-off lesson, how much you guide the students through the challenge is up to you. You can be more or less hands-on depending on how much of the project is done during club or class hours.

As part of the entry form you will be asked to note down how much you or another adult – for example, a STEM Ambassador – have helped the students with their projects.

STEM Ambassadors

STEM Ambassadors are placed all around the country and may be able to come into schools to speak with your STEM club or class – for example, to kick off the challenge.

STEM Ambassadors use their enthusiasm and commitment to encourage young people to enjoy STEM subjects. Involving a STEM Ambassador in the competition is optional but recommended as it will enhance the students' experience and learning.

To request a STEM Ambassador (subject to availability) please complete this form:
http://bpes.bp.com/stem-challenge/stem-ambassadors/

Challenge starter lesson

Equipment

- Water rocket kits (e.g. Rokit kits, but other kits are available)
- Bike pumps (stirrup pumps are quick and include a pressure gauge, but any pump will work)
- 1 or 2 litre clean fizzy drink bottles (make sure these contained fizzy drinks – fizzy drink bottles are designed to withstand high pressure, while still drink bottles are not)
- Thin card or plastic and tape, to develop streamlining and stabilising shapes
- Stopwatches

Remember to carry out a full risk assessment before attempting any practical activity. Water rockets can be dangerous. Read the operating and safety instructions contained in the water rocket kit, including maximum water level and pressure. Ensure students keep to the recommended safe distance when pressurising and launching, and wear safety goggles throughout the practical activity.

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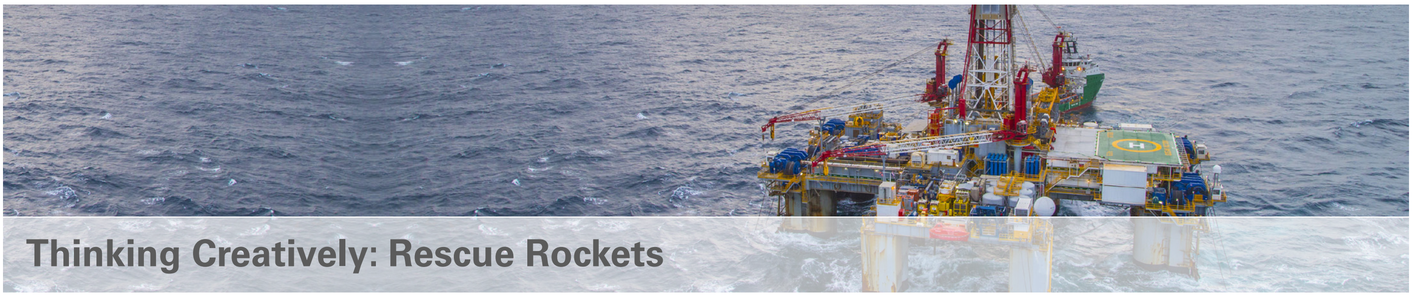

Thinking Creatively: Rescue Rockets

Introduction (10 minutes)

Please see *Introducing the Ultimate STEM Challenge*, above.

Ideas generation (10 minutes)

Having chosen Rescue Rockets, ask students to think about what factors might affect a rocket's performance and how high it will fly.

Give students a few minutes to discuss the following questions:

- What forces will act on the rocket as it moves through the air while the water propels it?
- What design factors might increase these forces?
- What design factors might decrease them?
- How can the rocket's design help make it stable during flight, as well as helping it reach as high as possible?

More able students:

- How might the rocket incorporate a parachute, to slow its descent?
- How might this parachute release at the right time?

Bring together their ideas on a board or flipchart.

Thinking scientifically about air resistance (10 minutes)

Students will gain the most from this topic if they have already covered the topics of forces, friction and resistance (e.g. air resistance).

Help students identify the source of air resistance: a moving object (in this case, the rocket) needs to push its way through molecules of gas. As these molecules rub on the outer surface of the rocket, they cause friction. Friction is a force that acts in the opposite direction to the thrust from the rocket 'engine' (the water escaping), slowing it down.

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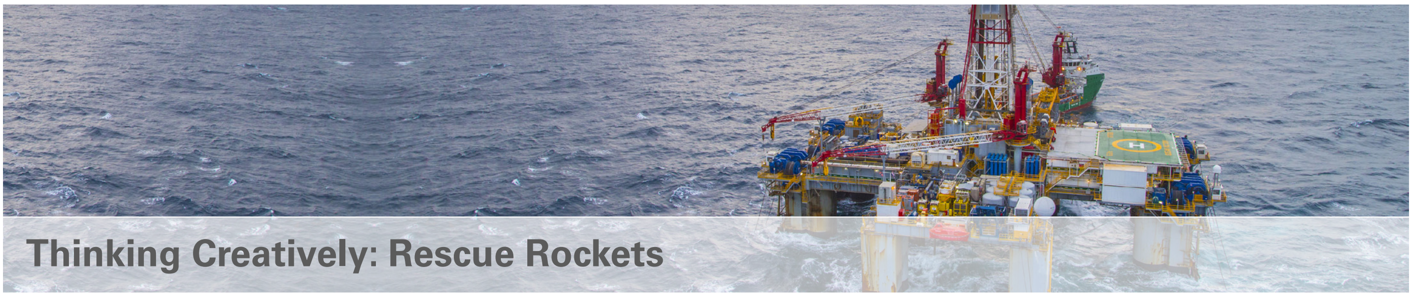

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Discuss how air resistance affects the motion of a parachute or racing car: the parachute is designed to maximise air resistance by having a large surface area, while the racing car is designed to have as small a surface area as possible, and smooth surfaces, both of which minimise air resistance.

Ask students to sketch the forces acting on a moving rocket, adding and labelling the upwards propulsive force and the downwards forces of air resistance force and gravity (more able students should be able to remember that gravity will always be acting on the rocket, even as it rises upwards).

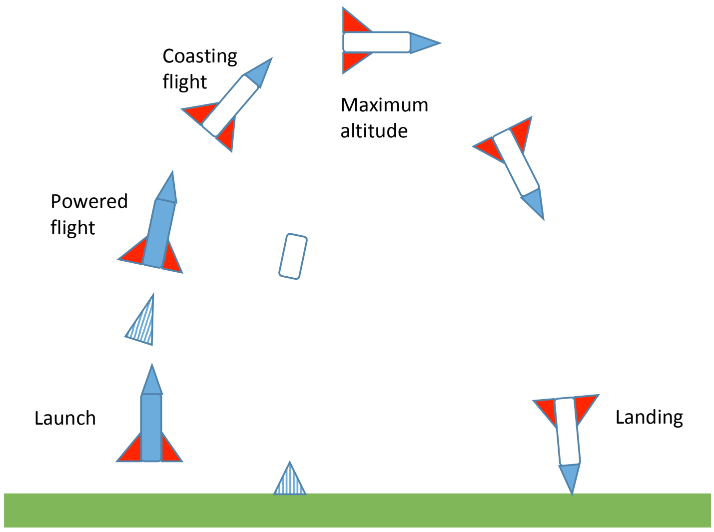
Discuss how these forces compare or balance during upwards flight and after the water has run out. Why does the rocket continue to coast upwards for a while, before falling?

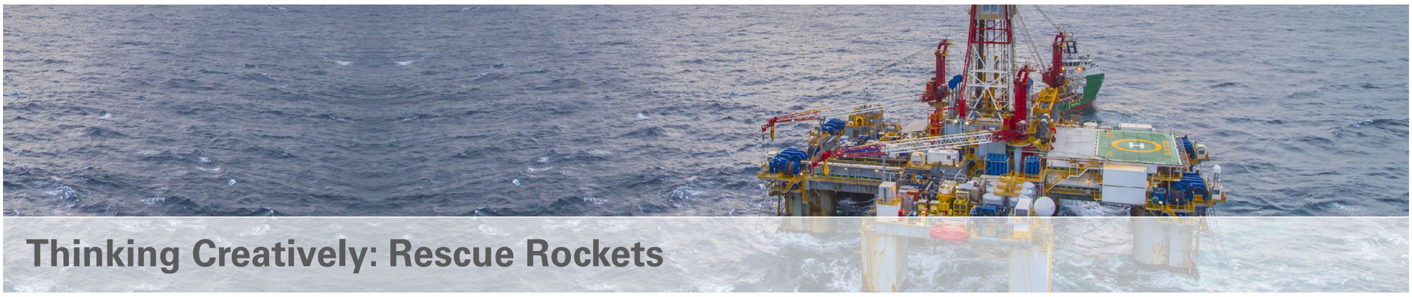
Measuring flight time or distance (25 minutes)

Ask students to brainstorm how they might plan, build and test a model water rocket. You may wish to show a water rocket kit and discuss how students might modify the design (perhaps minus any stabilising fins that come with the kit) to reduce air resistance and add stability.

Discuss and then demonstrate how students might use the equipment to find out which designs reach the greatest altitude and therefore can stay in the air for longer. Can students measure altitude directly, or will they need to measure another variable, such as the time taken until the rocket reaches the top of its trajectory?

Make clear that this is just one possible approach, and that you are using these model rocket kits to explore some simple ideas about streamlining. For their challenge, students need to be creative and test different designs and shapes, adding their own streamlining and stabilisation designs, using a range of bottle shapes, and perhaps for more able pupils, including a parachute to slow its descent.





Thinking Creatively: Rescue Rockets

- Demonstrate a water rocket and share any safety directions.
- Ask students to time the rocket's flight. Some kits, like Rokit, release automatically when they reach a certain pressure. How can they start their timer at the right time?
- Identify dependent, independent and control variables. For example, should students use the same quantity of water when testing their streamlining or stability fins, or the same design when testing different quantities of water or pressure? (Make sure students don't exceed recommended levels. Some kits release at a set pressure so students will need to test changes in water quality only.)
- Agree on how best to measure flight times, and how students will record their results.
- Allow each group to try using the equipment. Encourage each group to discuss among themselves how they might improve the equipment to make their investigation a better one, for example by each timing the rocket to find an average time, or how else they might test their designs using a different approach.
- Emphasise that groups need to use both their design and science skills, first designing and making model rockets, and then planning and completing an investigation to test their designs and identify the best.

Health and safety notes

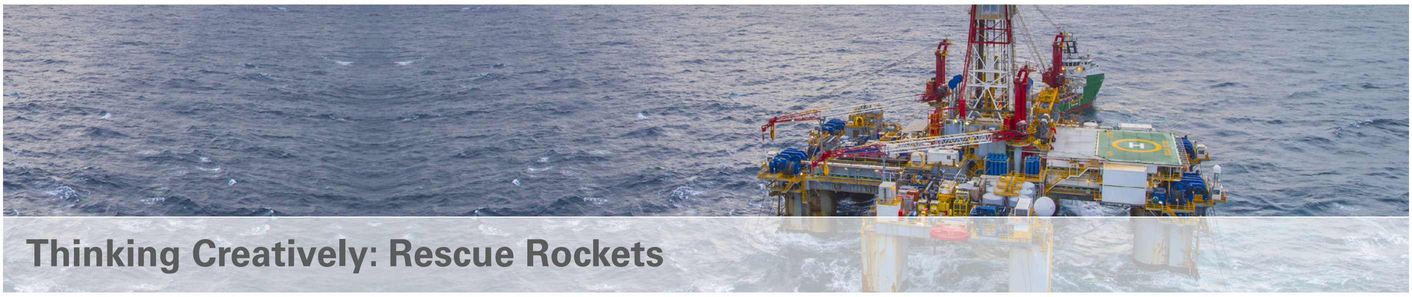
Remember to carry out a full risk assessment before attempting any practical activity. Water rockets can be dangerous. Read the operating and safety instructions contained in the water rocket kit, including maximum water level and pressure. Ensure students keep to the recommended safe distance when pressurising and launching, and wear safety goggles throughout the practical activity.

Addressing the Challenge (10 minutes)

Adapt your delivery here to suit your students' abilities.

The team should consider the following questions:

- Who will be responsible for what?
- What do they need from school?
- How will they investigate and measure how well their water rocket designs work (or not)?



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Use the measuring flight time experiment to open up a discussion around how best to measure how high students' rockets can fly. Consider the following:

- How to design and build model rockets that control for variables students don't want to test or vary, such as mass, but which allow them to explore different shapes and designs.
- Sources of error, especially errors in timing.
- Ideas for improving the accuracy of measurements, for example by getting every team member to time each flight and finding the average.
- Ways to make their different design ideas sufficiently different so that improvements or patterns are large enough to be measurable.

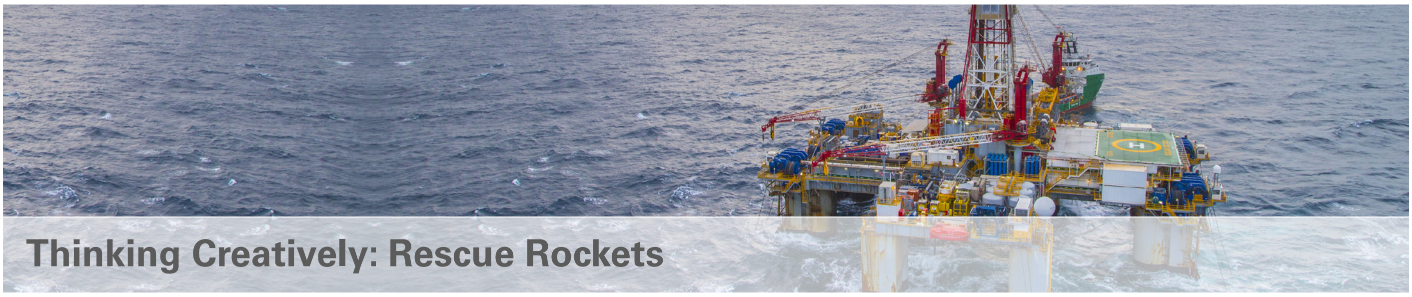
Students need to do the following:

- Create the rocket designs they will test – how can they identify the most aerodynamic and stable shape? (Hint: adding mass at the nose can add stability by balancing the mass of the water at the other end. But too much mass may decrease maximum altitude and flight time.) How might some students also incorporate a parachute? How would this release?
- Turn each design into a model water rocket, thinking about how to control other variables (Hint: use the same quantity of water when testing designs, and the same design when testing different quantities of water or pressure.)
- Adapt today's experiment, or come up with their own way to test their designs.
- Decide on any equipment they will need to try out their ideas.
- Order the equipment they will need for the next session.
- Plan how they will create and present evidence of their research, creativity, designs, investigation and results, for example using photos, video clips and written documents.

Make sure that students are clear that they don't have to use the demonstration equipment – do they have any better ideas?

Tips

- Help students limit their investigations to suit the time you have. For example, it might not be possible to test different water quantities as well as designs. Better to keep it simple and focused.



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- Allow time to repeat tests so they can check the reliability of their results and/or refine their method.
- The testing method should be reproducible. In other words another scientist should be able to repeat it to check the results.
- Remember that their designs should also be practical so the water rocket would attract attention and help save lives in real life.

? Research (independent learning)

Encourage students to carry out independent research before they begin to create their water rocket designs:

- How high do distress flares travel?
- What lightweight lights (e.g. red LEDs) could students include in their design, to attract attention?
- How and where will they attach these to their rocket?
- How can they solve any stability problems, for example by adding a little weight to the nose?
- How does the high pressure water propel the rocket through the air?
- How are real rockets made streamlined and stable?

? What next?

This lesson plan is designed to start students off but it is up to you and your students as to how far they now take the challenge.

To find tips and advice for your students, including judging criteria, download:

- How to create a winning video
- How to create a winning presentation
- To find out more about the Ultimate STEM Challenge visit www.bp.com/ultimatestemchallenge