Water Rokit

Activity Day

Ages: 8-14 years

Kit required:

- NASA stickers
- Card
- Sticky tape
- Eggs (optional)
- Pens
- Water
- 1 litre or 1.5 litre empty recycled carbonated fizzy pop bottles / and extras for (egg experiments)
- Cotton wool (stuffing)
- Decoration materials of choice
- Stirrup pumps
- **1 Water Rokit per group** (and a spare)
- Water containers (if no water on tap)

N.B: See the last page for a printable certificate template to hand out at the end of the day to confirm that your students have qualified as Junior Rocketeers.

Please ask your group the questions in orange in this document, and wait for them to think and suggest answers before joining in.

Contact Charlotte Harverson – Head of Education with any questions at: charlotte@waterrokit.com or 07730 777219.

Introduction

Today is a Rocket and Space Day.

By the end of the day, you will all be a qualified 'Junior Rocketeer' – the things you learn today are the same principles that NASA and SpaceX use when they launch their Space rockets into Space.

Question 1: Ask your group — Why are Space rockets important?

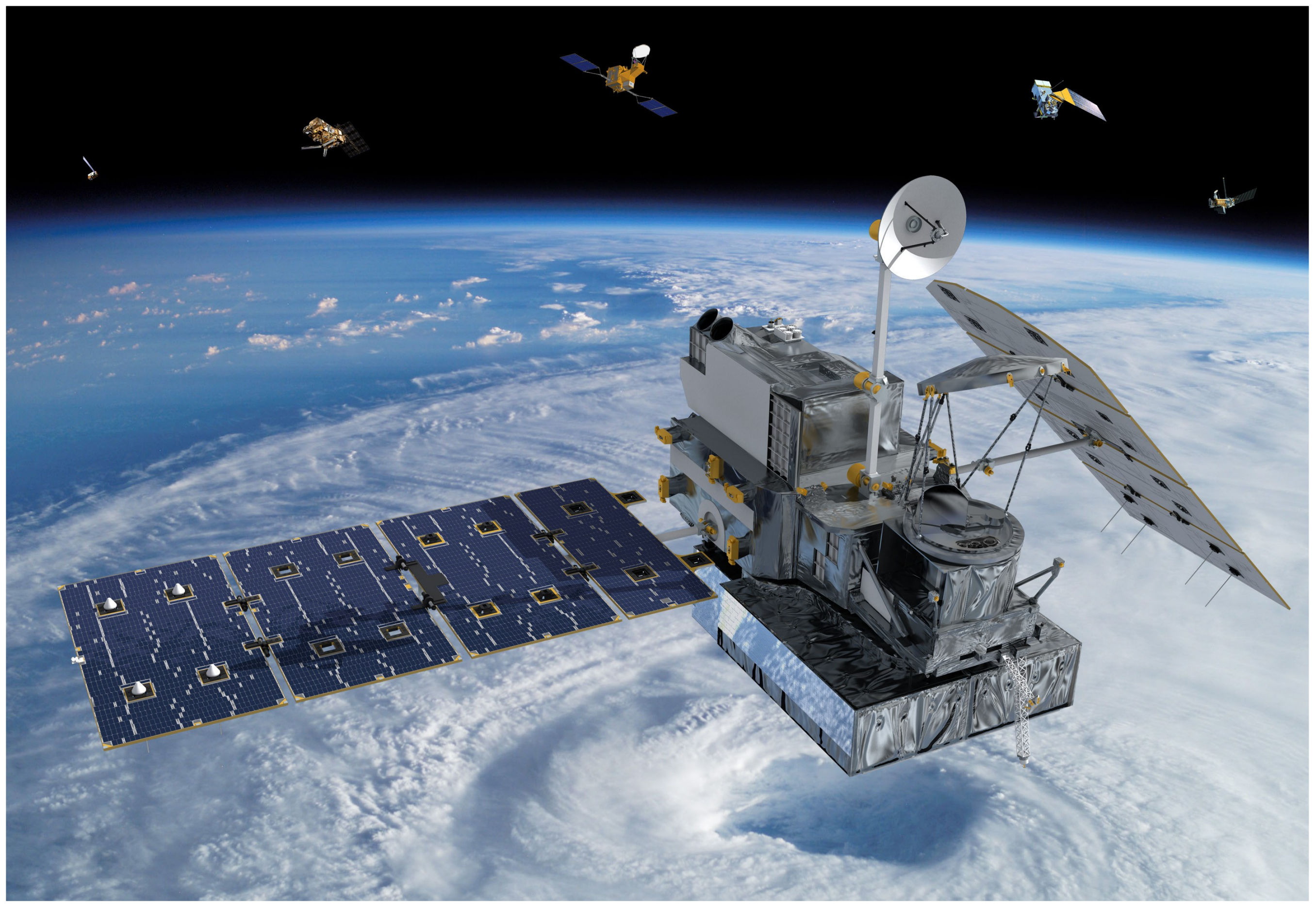
Rockets deliver satellites to Space where they can begin to do their important work. Without rockets, we wouldn't be able to:

- Use our mobile phones.
- Watch a lot of our favourite television shows.
- Find out the weather forecast.
- Navigate with Global Positioning System (GPS) – use a sat nav in the car.
- Explore our solar system in detail, and lots more.

You have probably used satellites for your daily tasks already today.

Question 2: What is a satellite?

A satellite is a moon, planet, or machine that orbits a planet or star. For example, Earth is a satellite because it orbits the Sun. Likewise, the Moon is a satellite because it orbits Earth. Usually, the word 'satellite' refers to a machine that is launched into Space and moves around Earth or another body in Space.



Question 3: How many satellites orbit the Earth?

There are at least 6,000 satellites that orbit the Earth, and this number is increasing all the time – satellites are very important to us all on planet Earth.

Here are some of the good things they do (in more detail):

- Crops – the weather monitored from Space allows farmers to produce their crops efficiently and harvest them at the correct time.
- Weather patterns – weather is monitored from Space. Satellites can also predict dangerous weather fronts like hurricanes.
- Communications – mobile telephone communication is transmitted in the form of microwaves.
- Navigation – GPS – Waze/Google maps – these satellites often work in groups of three to pinpoint your destination. Your sat nav is handy when you are travelling in a car or on a boat.
- Imagery of the Earth below (satellites have even helped archaeologists find ancient buried civilisations dating back thousands of years).
- Pollution is tracked and quantified by satellites – satellites measure the ozone layer, which absorbs nearly all of the Sun's harmful ultra-violet light.
- Research our galaxy and beyond.

Fun fact: The first artificial satellite, called Sputnik 1, was launched in 1957!

Question 4: How many miles per hour does a satellite travel in orbit?

A satellite that is close to the Earth, in what is called a ‘Low Earth Orbit’, travels at approximately 17,500 miles per hour. To put that into perspective, the fastest aeroplane (jet) in the world reaches speeds of 2,100 miles per hour. So, it moves super-fast!

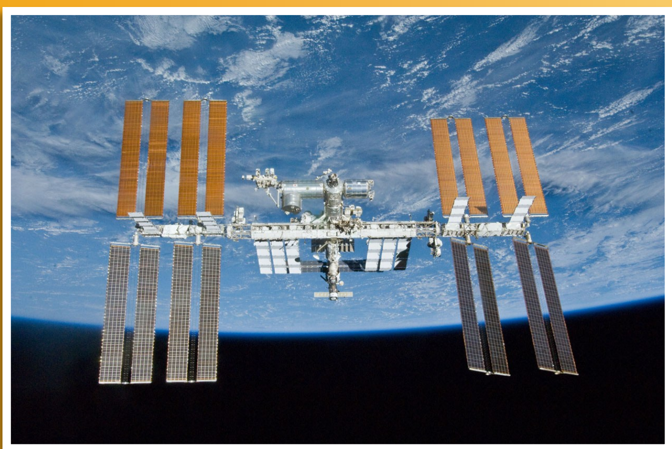
Some satellites operate even higher. The higher it is, the slower it needs to travel to stay in orbit.

Question 5: How long does it take for a satellite to orbit the Earth?

In Low Earth Orbit, it takes about 90 minutes to go around the Earth once.

Question 6: What is the ISS?

ISS stands for **International Space Station.** This is where astronauts and scientists fly to on a rocket and conduct important experiments in Space. The International Space Station is situated about 250 miles high in the sky in Low Earth Orbit. It travels about 17,500 miles per hour, and on a clear night (if you are in the right place on Earth) you can see it travel across the sky.



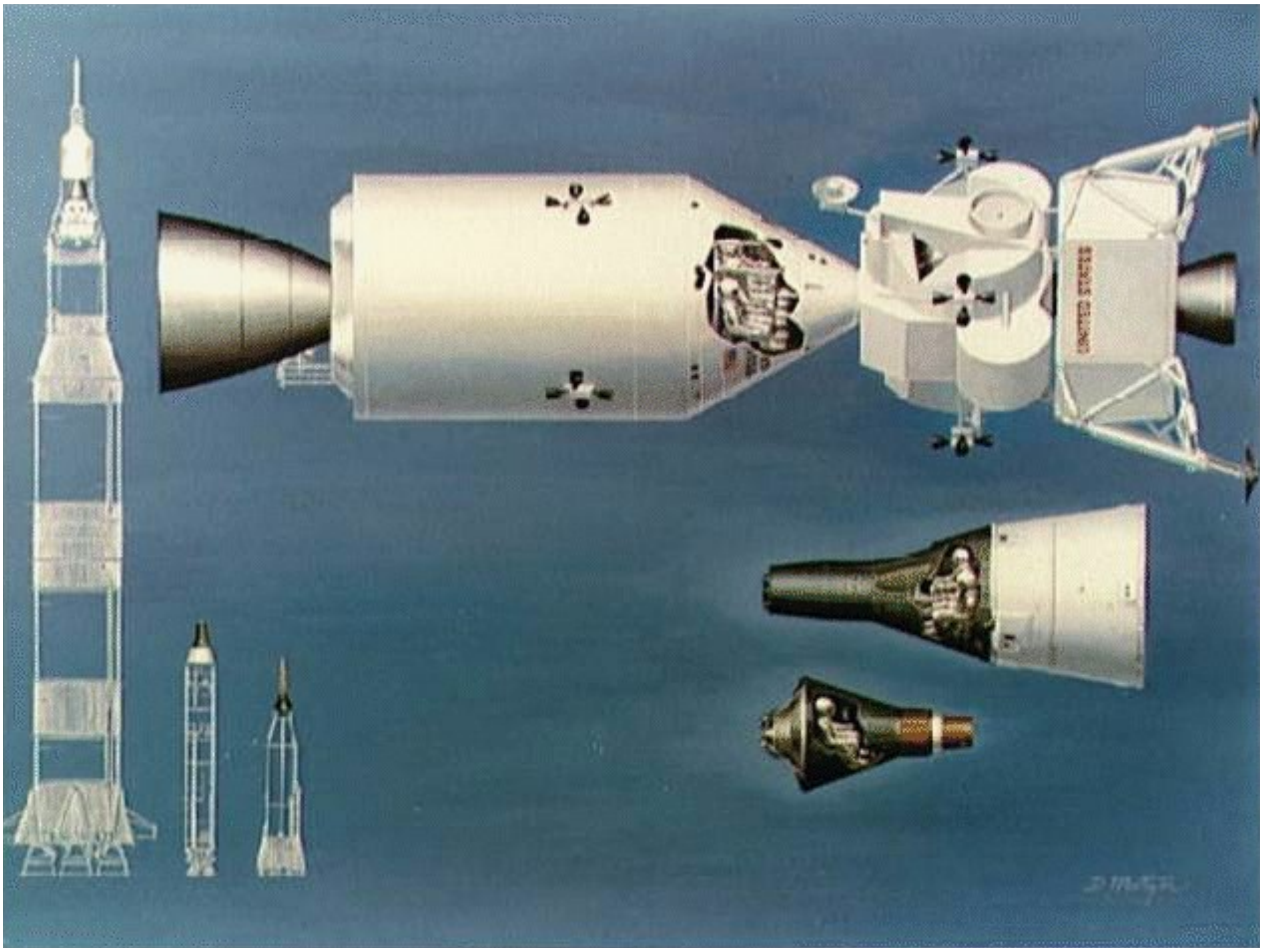
Question 7: How fast does a rocket travel to get into Space?

A rocket needs to accelerate to about 17,500 miles per hour to get into low Earth orbit. If it is travelling to the Moon, it needs to go even faster, at around 25,000 miles per hour.

Question 8: What is a payload?

A payload is the passenger or cargo that sits on top of a Space rocket. If we are launching people into Space, we need to think about getting our astronauts up into Space and down again safely.

But for satellites, cargo, or research equipment, we can launch this equipment up, and leave it there.



Question 9: What does it take to launch a rocket upwards? What do we need to think about?

We need to generate a lot of energy which creates **thrust** – this pushes the rocket up into the sky.

Have you ever heard of Sir Isaac Newton? He established a universal law saying – “for every action, there is an equal and opposite reaction”.

Launching a rocket relies on Newton’s Third Law of Motion. A rocket engine produces thrust through action and reaction. The action of the engine produces hot exhaust gases that flow and shoot out of the back of the engine at very high speed. In return, a thrusting force is produced in the opposite reaction, pushing the rocket upwards. (We will test and see this when we fly the Water Rokit.)

Picture a octopus in the water. An octopus sucks the water into its body, then shoots it out as a jet behind, which pushes the octopus forward.

Watch this quick example of an octopus jet propulsion at 1:17!

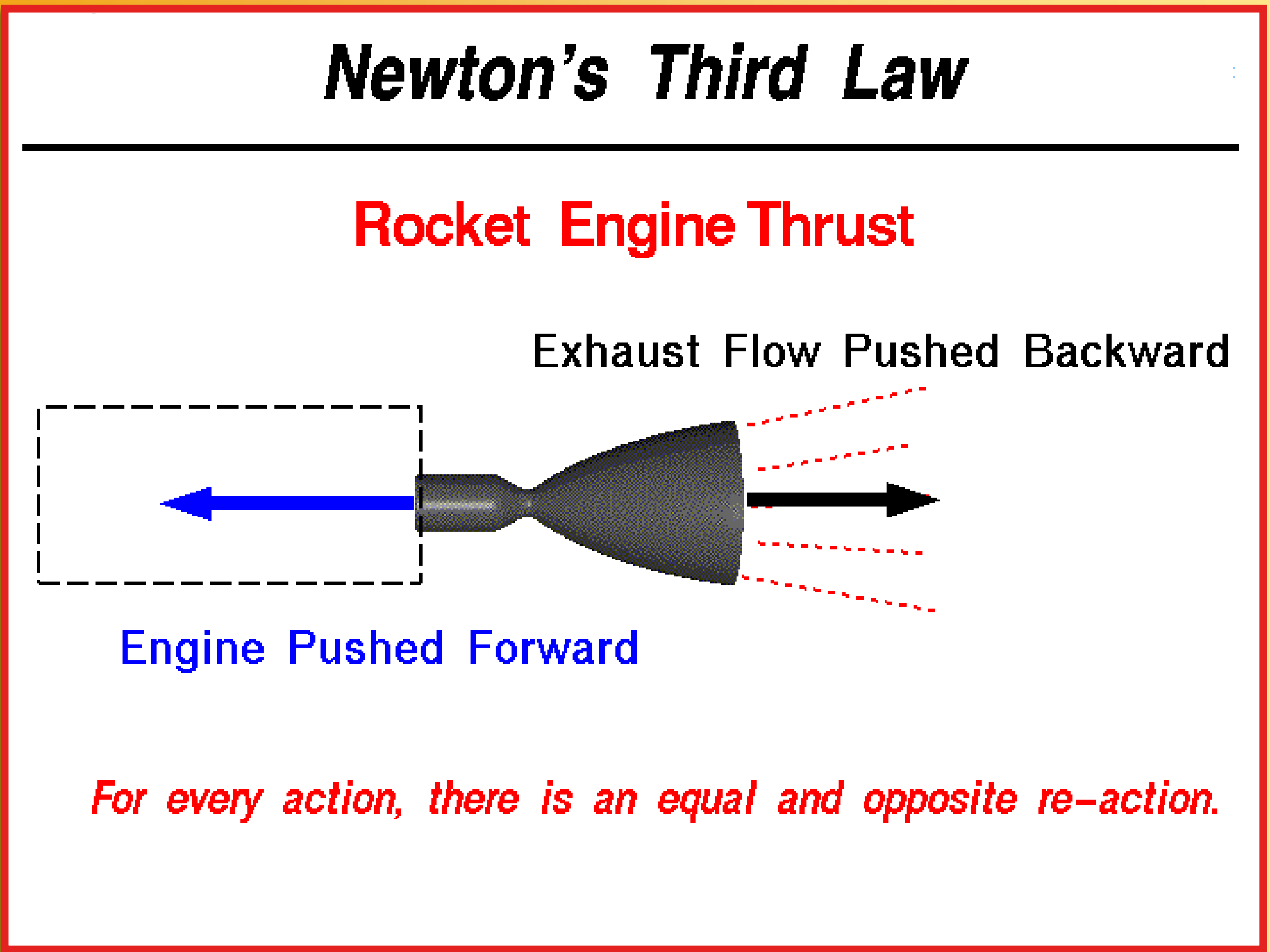
Question 10: Let's test Newton's Third Law of Motion right now! Let's all stand up – what happens when we jump up and down?

Ask your group to jump as high as they can.

How are you launching yourself upwards? Your feet are pushing into the ground which pushes your body upwards.

To launch the Water Rokit, we need to **push** something down to **push** and launch the rocket up.

In rocket lingo – we need to create **'thrust'.**



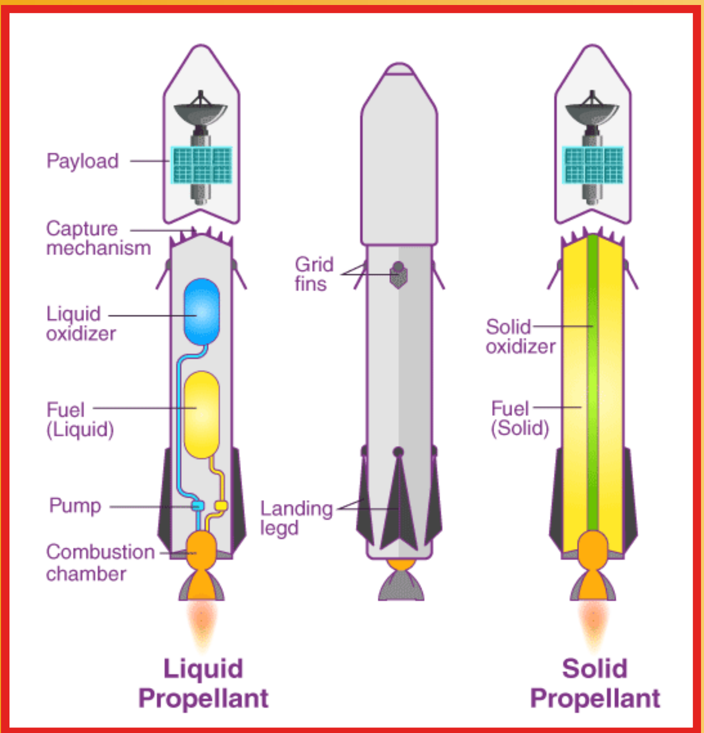
Question 11: How do we generate thrust?

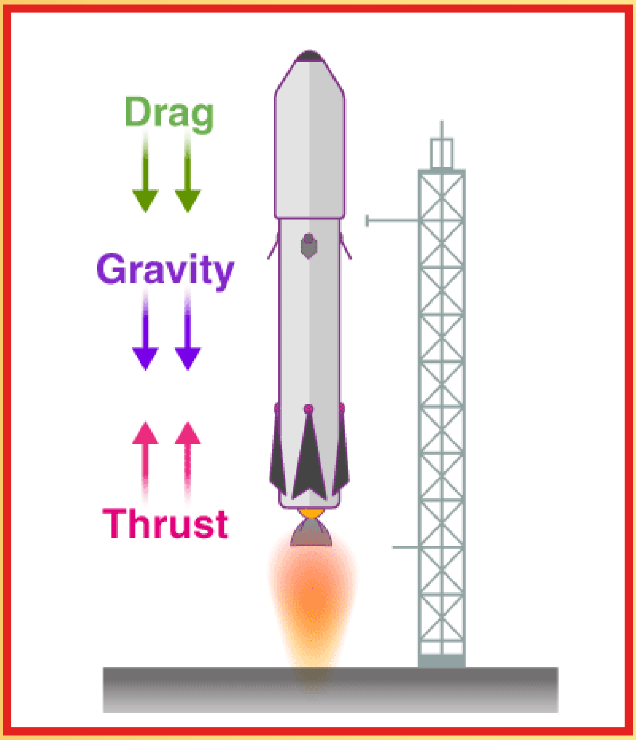
We need fuel.

In the Water Rokit we are going to launch today, our fuel is water, but a Space rocket needs a special, powerful rocket fuel. This fuel is either liquid (like the fuel in your car), or solid (like a firework).

This fuel is then mixed with oxygen that is so cold it turns to liquid, and is called an oxidiser, or LOX for short.

When these two substances are mixed together at a very hot temperature, it causes a reaction. This process is called combustion. It burns the fuel super quick, generating exhaust gases, and it is this that creates huge amounts of thrust that drives the rocket upwards at great speed through Earth's atmosphere into Space.





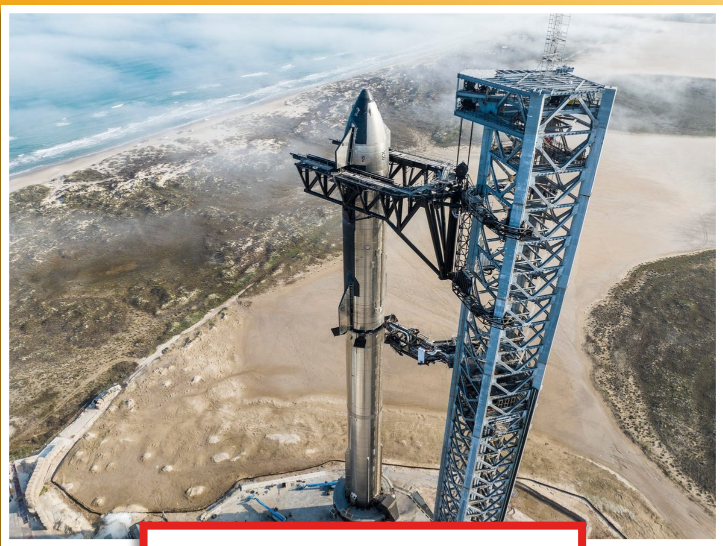
Question 12: How do we make sure that the rocket goes straight up, and doesn't shoot off to the left or right? How do we keep it stable?

Our Water Rokit has **fins** on it. These fins make the rocket stable as it climbs through the air.

On big rockets, the engines adjust a little bit to the left, and a little bit to the right, if needed, like the steering wheel on a car. This is called **gimbaling.** This helps stabilise the rocket.

(Mass distribution and pressure are also very important in rocketry, but we will save that for another time.)

Just to give you a sense of perspective regarding the sheer size and power of these monster rockets – NASA's Saturn 5 rocket, from the Apollo missions that put astronauts on the Moon, was the **height of a 36-storey building.** It weighed 3,000 tons and burned fuel at 15 tons per second. (NASA's Artemis SLS, that recently flew around the Moon, had even more power than the Saturn 5, and SpaceX's new rocket that they are developing, called the Starship, will be almost **twice** as powerful as this.)



SpaceX's Starship

NASA's SLS

Imagine this 36-storey building lifting off the ground with flames burning 15 tons of fuel per second. The engines could swing gently back and forth, moved by gigantic hydraulic rams, so if the rocket started to turn one way and veer off course, the engines would pivot, (whilst still burning 15 tons of fuel per second) keeping the rocket on its correct course, known as its **trajectory.**

There is **one** more important thing the rocket needs to help it travel.

It needs to be aerodynamically **streamlined.** If you think about a boat in the water, or a dolphin, they are designed, and have evolved, to cut and slide through the water. The same can be said for a rocket. We need to make the rocket as sleek and streamlined as possible. This helps the rocket move through air as easily as it can at great speeds.

The faster the rocket travels, the more wind resistance (drag) it will face. Before the rocket enters the vacuum of Space, the atmosphere is as **thick as soup!**

On our Water Rokit, the bottle and fins will help our rocket travel through the air.

Experiments & Activities

Experiments:

Watch the following video for a simple, practical balloon experiment illustrating Newton's Third Law of Motion. *(This experiment is great fun to do with your group before you fly the Water Rokit.)*

Balloon on a string

Watch the following video for an illustration of the effects on the body in the vacuum of Space, where there is no atmosphere.

Marshmallow experiment

Activities:

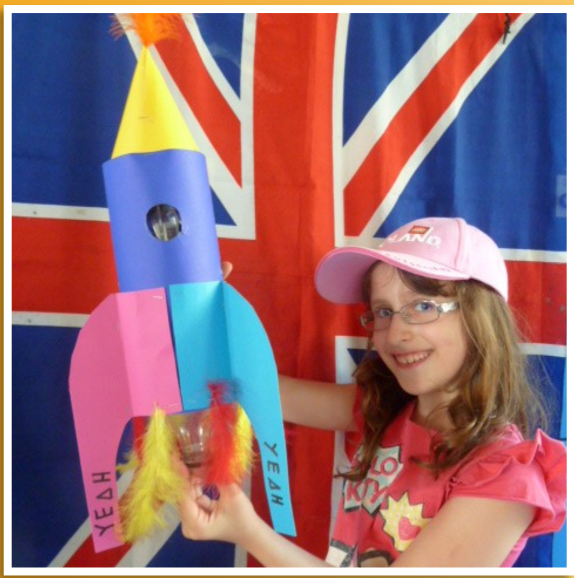
Now, we are going to **decorate our rockets.** Get some stickers and other craft materials and customise your rockets.

Lower age groups: Simply add stickers.

Older age groups: Vary the rocket design by considering…

Cones to add to streamlining

Making things to increase drag

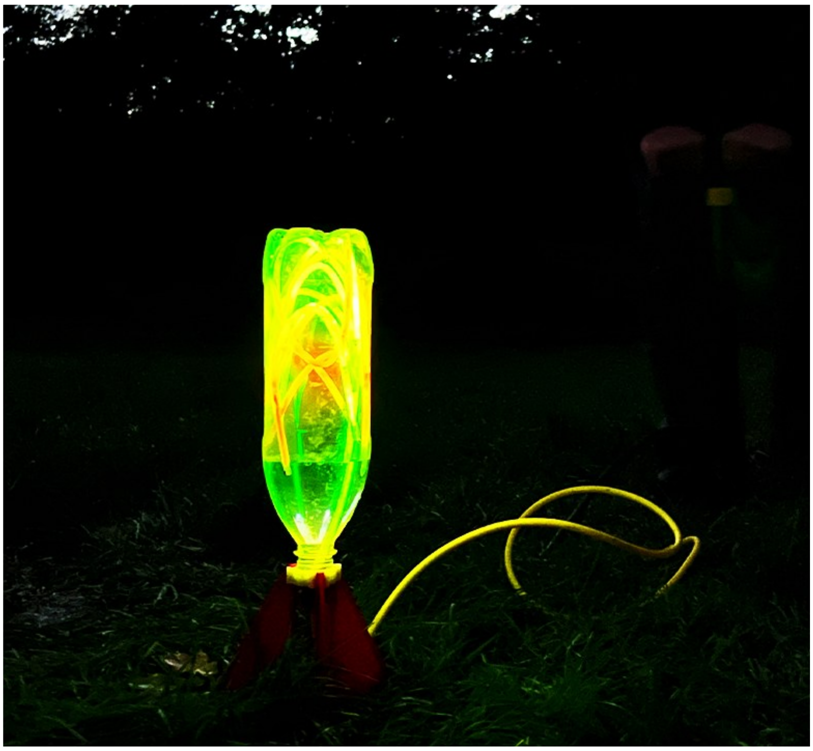


Tip: 'Drag' is the force that acts on the surface of an object moving through a gas or liquid that slows it down. It acts in the same line of motion as the object, but in the opposite direction.

Adding a "payload" by attaching another half bottle containing an egg protected with cotton wool. (See page 16 for details of the Astronaut Egg Experiment.)

What do you think will happen to the egg?

Alternatively, how about glow sticks or LED lights?



Tip: Whilst the children make their rockets, hand them a Space quiz to complete.

Now Let's Go Outside and Test Our Rockets!

Questions About Rockets

- Why are they shaped like this?
- What do you notice about your rocket?
- How do you think you can make it go higher?

Rocket Launch Practical

Launch a rocket as per the instructions and **assembly video**.

- Launch a rocket with more or less water in the bottle. Get the kids to feedback what happens.
- Add some cardboard fins on the side of the Rokit to increase drag.
- Make some different nose cones for the Rokit to see the effect.
- Launch the Rokit at an angle (space allowing). We recommend the use of a piece of guttering to launch your rocket.
- The egg experiment (attach a payload to your rocket). Return your egg to Earth in one piece – (see instructions for your egg experiment on page 16).
- Show photos / videos.

The Astronaut Egg Experiment

As a trainee Junior Rocketeer, your mission is to launch an 'Astronaut Egg' into Space, landing it safely in one piece.

We'll be creating an extension to your rocket booster bottle by adding a further payload containing your Astronaut Egg. We will do this by adding the bottom of another plastic bottle, (that is the same size as the booster bottle) and securing it on top with sticky tape.

Ask your group how they think they might protect their Astronaut Egg and prevent it from cracking on impact.

How NASA prepares for a mission

Before a mission commences at NASA, the team will agree on their mission objective. They will define their parameters by outlining what key steps are needed before they commence their mission, and what is required to reach their objective successfully.

At the end of the mission, they assess what parts of the mission were successful, and what could be improved for next time – they have a big checklist that they tick off.

Remember that often the biggest lessons learned in life are from the mistakes we make, as this is how we truly learn from our experiences. It's about enjoying the journey, not just getting to the destination. Failure cannot deal with persistence. So, fail forward and try again.

Adopt this method when experimenting:

Test/Measure/Improve/Optimise

Mission Objective – To launch and return your Astronaut Egg to Earth in one piece

Step 1 – Decorate your Astronaut Egg.

Step 2 – Create your additional payload by cutting another plastic bottle (the same size as your booster bottle) in half.

Step 3 – Protect your egg with different types of soft materials and packaging. Bubble wrap / cotton wool – anything you can bring from home that will soften the impact on re-entry.

Step 4 – Place your astronaut into the bottle with its protective covering.

Step 5 – Attach your payload on top of your booster bottle with sticky tape, ensuring that your astronaut is secured inside.

Step 6 – Execute your mission by launching your rocket.

Step 7 – Record your findings and observations.

- Was your mission successful and why? What could you further improve for next time?
- Was your mission unsuccessful and why? What could you improve for next time?

The science behind the experiment

Why does an Astronaut Egg that is protected with packaging and materials (such as cotton wool), stand a much better chance of landing in one piece than an egg that is left unprotected?

Impact Force

Impact force is a force that delivers a high impact in a relatively short period of time. It occurs when two objects collide. It's the result of one object falling or colliding onto, or slamming into, another object. (You may have experienced this if you've ever fallen off a bike or scooter. Usually, the faster you're going, the more it hurts.)

When your egg is falling, it contains energy. The higher the fall, the faster it goes, so the more energy it has. So, if we can pack the egg with soft materials, this will help absorb and soak up this energy on impact.

Ask your team how else they could reduce the energy of impact.

How about slowing your Water Rokit down by either fitting a parachute, by using a bigger bottle, or by adding less water to start with? Record the difference these factors make.

Why understanding 'Impact Forces' is a great example of illustrating the effects of Newton's Third Law of Motion

When the Water Rokit with its Astronaut Egg hits the ground, there will be an 'impact force' to the ground, and the ground will have 'an equal and opposite reaction'. (Just like when we spoke about the octopus, and the thrust of a rocket.) The dropped egg will absorb the forces from the collision upon landing and react. So, packing the egg in soft protective materials means that the energy will be absorbed by the material, minimising the energy absorbed by the egg.

(If done correctly, this will leave the egg intact, in one piece, and ready to be eaten for breakfast with buttered soldiers – yummy!)

If you would like to develop this experiment further, download Professor Simon Foster's (the Rocket Man from Imperial College in London) **instructions for adding a nose cone and parachute**, plus some **great handouts** for your students so they can attribute their Astronaut Egg to a real-life astronaut.

At Water Rokit, we recommend creating teams, each with their own Water Rokit and egg which is named after a real-life astronaut from a different country. (See the links above for Simon Foster's guides.)

Try testing this with different sized bottles – 1 litre or 2 litre.

Enjoy, and happy rocketeering!

CERTIFICATE

OF ACHIEVEMENT

This certificate is proudly awarded to:

For your hard work and enthusiasm in your
Water Rokit Activity Day, leading you to become a
qualified Junior Rocketeer with Water Rokit.

Water Rokit

WATER ROKIT
SENIOR ROCKETEER

Water Rokit