Water Rokit

Activity Day

Introduction

Today is a Rocket and Space Day.

By the end of the day, you will all be a **qualified 'Junior Rocketeer'!**

To be presented with page 2 of the session.

"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: Why are Space Rockets Important?

To be presented with page 2 of the session.

Question 1: Why are Space Rockets Important?

Rockets deliver satellites to Space where they can begin to do their important work.

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

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To be presented with page 2 of the session.

“Rockets deliver satellites to Space where they can begin to do their important work.

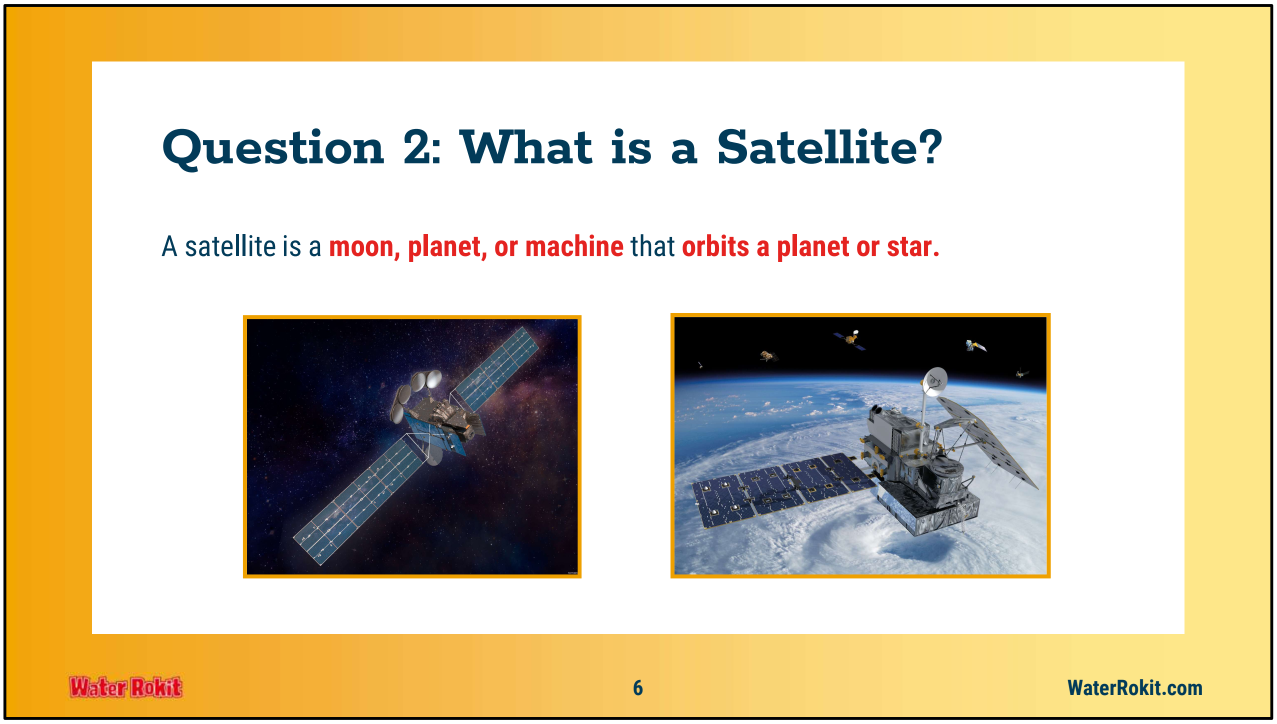
Without rockets, we wouldn't be able to:

- 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?

To be presented with page 3 of the session.



To be presented with page 3 of the session.

"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?

To be presented with page 4 of the session.

Question 3: How Many Satellites Orbit the Earth?

There are **at least 6,000 satellites that orbit the Earth.**

Here are some of the good things they help with:

- **Crops**
- **Weather patterns**
- **Communications**
- **Navigation**
- **Imagery of the Earth below**
- **Pollution**
- **Research our galaxy and beyond**

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To be presented with page 4 of the session.

"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?

To be presented with page 5 of the session.

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.**

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

To be presented with page 5 of the session.

"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?

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To be presented with page 5 of the session.

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.

To be presented with page 5 of the session.

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

Question 6: What is the ISS?

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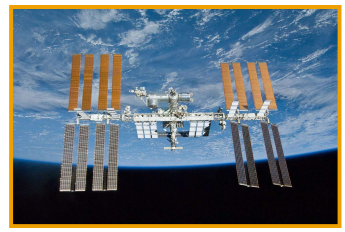
To be presented with page 5 of the session.

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.**



To be presented with page 5 of the session.

"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?

To be presented with page 6 of the session.

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.**

To be presented with page 6 of the session.

"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?

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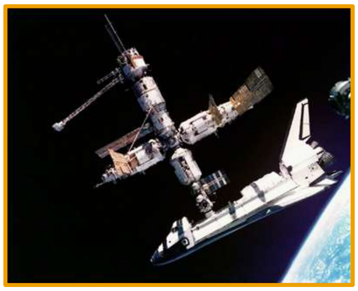
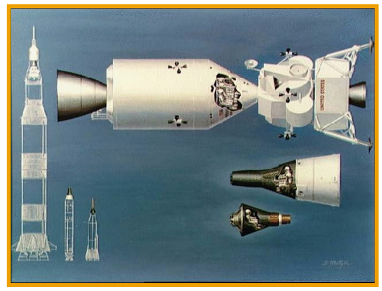
To be presented with page 6 of the session.

Question 8: What is a Payload?

A payload is **the passenger or cargo that sits on top of a Space rocket.**





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To be presented with page 6 of the session.

"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?

To be presented with page 7 of the session.

Question 9: What Does it Take to Launch a Rocket Upwards?

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".**

Watch this quick example of a squid jet propulsion!

To be presented with page 7 of the session.

"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 the quick example of an octopus jet propulsion at 1:17.

Question 10: Let's Test Newton's Third Law of Motion! What Happens When We Jump Up & Down?

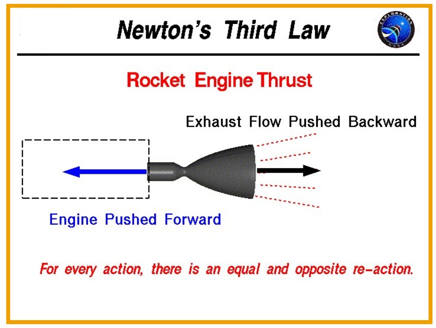
To be presented with page 8 of the session.

Question 10: Let's Test Newton's Third Law of Motion! What Happens When We Jump Up & Down?

Jump as high as you can!

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

For every action, there is an equal and opposite re-action.



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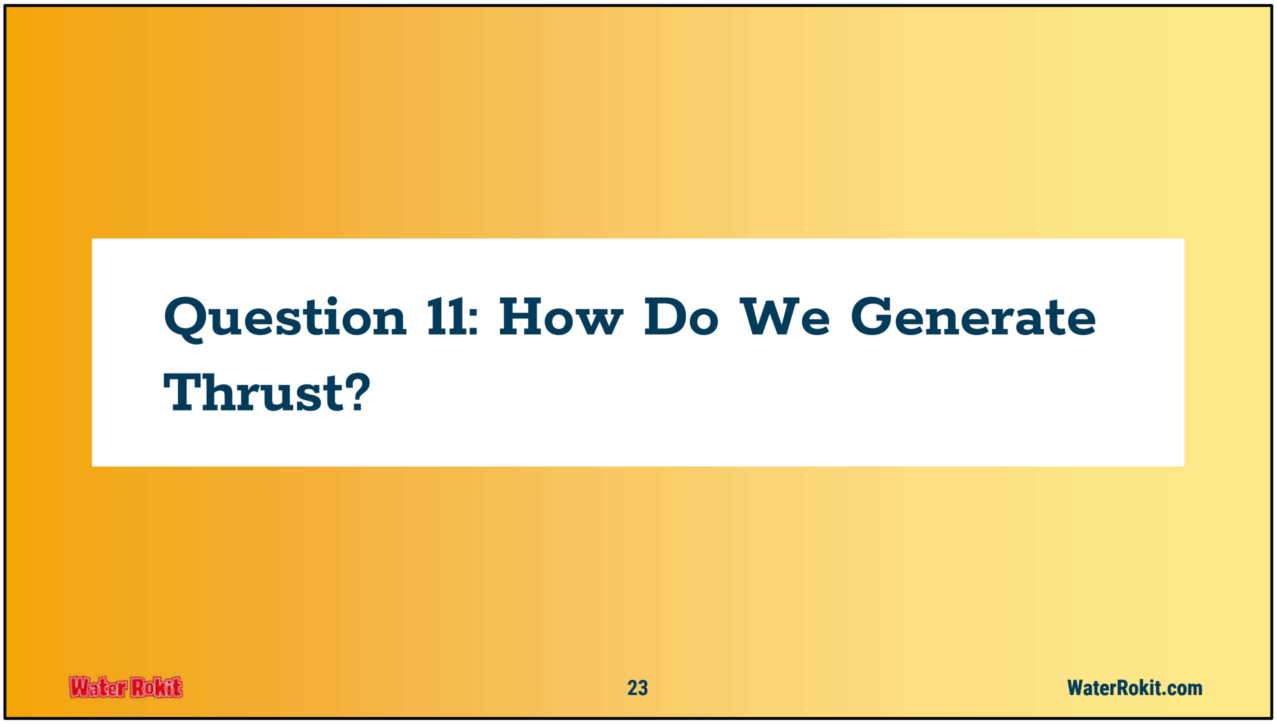
To be presented with page 8 of the session.

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'."**

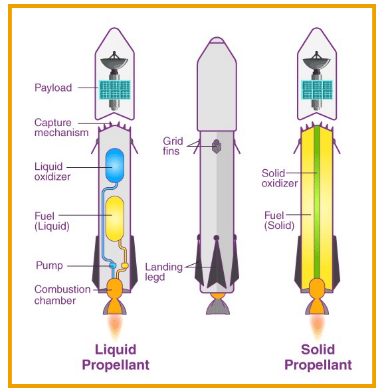


To be presented with page 9 of the session.

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).



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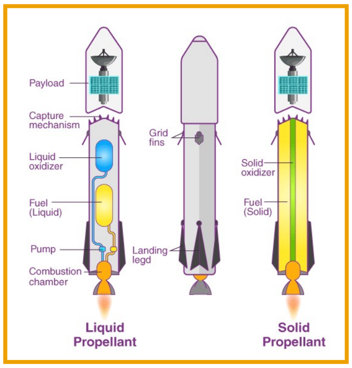
"We need fuel.

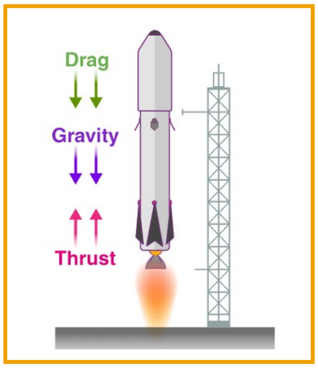
In the Water Rokit we are going to launch today, our fuel is water, but a Space rocket needs a special, powerful rocket fuel. This fuel is either liquid (like the fuel in your car), or solid (like a firework).

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 11: How Do We Generate Thrust?





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To be presented with page 9 of the session.

Question 12: How Do We Make Sure the Rocket Goes Straight Up and Doesn’t Shoot Off to the Left or Right? How Do We Keep it Stable?

To be presented with page 10 of the session.

Question 12: How Do We Make Sure 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. This is called **gimbaling.** This helps stabilise the rocket.

To be presented with page 10-11 of the session.

"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.)

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."**

Question 12: How Do We Make Sure the Rocket Goes Straight Up and Doesn't Shoot Off to the Left or Right? How Do We Keep it Stable?

There is **one** more important thing the rocket needs to help it travel. It needs to be aerodynamically **streamlined.**

We need to make the rocket as sleek and streamlined as possible.

The faster the rocket travels, the more wind resistance (drag) it will face.

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To be presented with page 11 of the session.

"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."

Question 13: Why Reuse a Rocket?

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Imagine every time you boarded an aeroplane or jumped into a car it was **only good for a single journey.**

How much would it cost? It's just **too wasteful,** isn't it?

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How much would it cost? It's just **too wasteful,** isn't it?

Question 13: Why Reuse a Rocket?

SpaceX have been working on **reusable rockets** since 2011.

On their **Falcon 9 Rocket,** which is used to take satellites, cargo and people into Space, the **booster** section of the rocket **returns to Earth and lands,** often on an unmanned ship called a 'Drone Ship'. This dramatically reduces the cost of a Spaceship reaching orbit.

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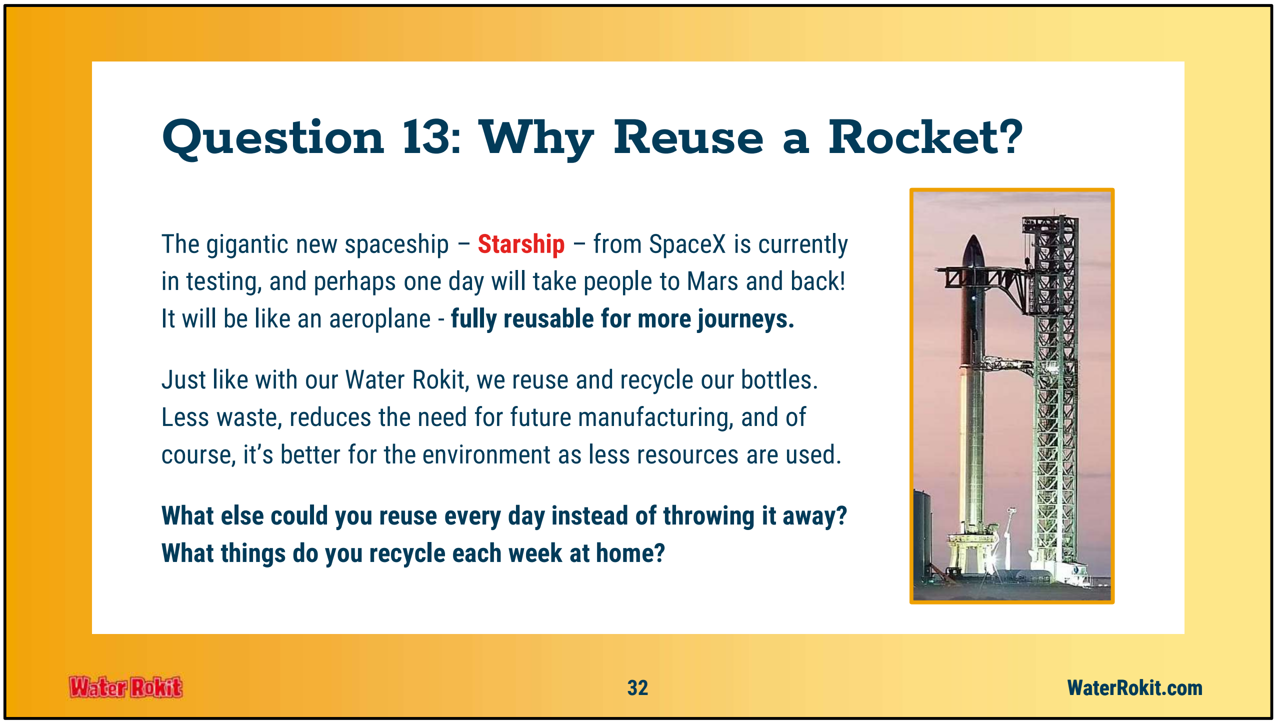

The gigantic new spaceship – **Starship** – from SpaceX is currently in testing, and perhaps one day will take people to Mars and back! It will be like an aeroplane - **fully reusable for more journeys.**

Just like with our Water Rokit, we reuse and recycle our bottles.

Less waste, reduces the need for future manufacturing, and of course, it's better for the environment as less resources are used.

What else could you reuse every day instead of throwing it away?

What things do you recycle each week at home?

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)

Activities & Experiments

Experiments:

Watch this simple, practical balloon experiment illustrating Newton's Third Law of Motion.

Balloon on a string

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

Marshmallow experiment

To be presented with page 12 of the session.

Watch the "Balloon on a string" 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.)*

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

Activities & Experiments

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.

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To be presented with page 12 of the session.

“Now, we are going to **decorate our rockets.** Take your NASA stickers and customise your rockets.”

Activities & Experiments

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.

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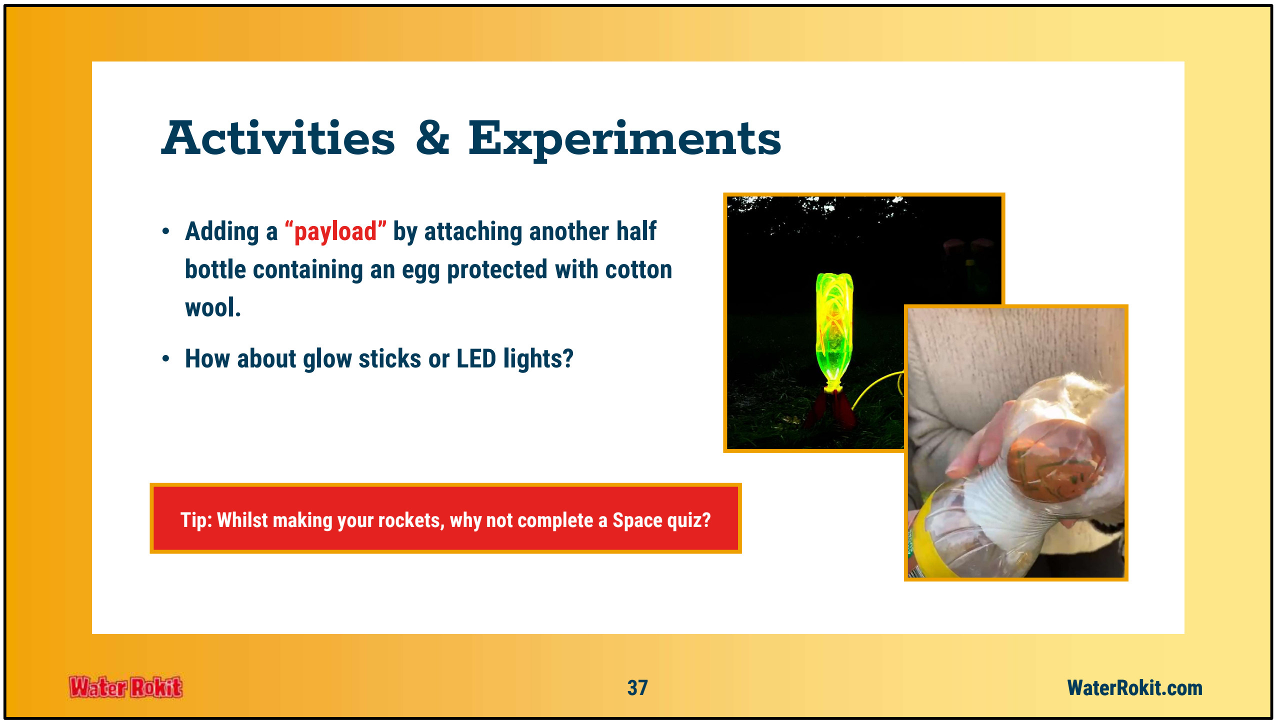

To be presented with page 14 of the session.

"Adding a **"payload"** by attaching another half bottle containing an egg protected with cotton wool. (See slide 39 for details of the Astronaut Egg Experiment.)

Alternatively, how about glow sticks or LED lights?"

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

Let's Go Outside and Test Our Rockets!

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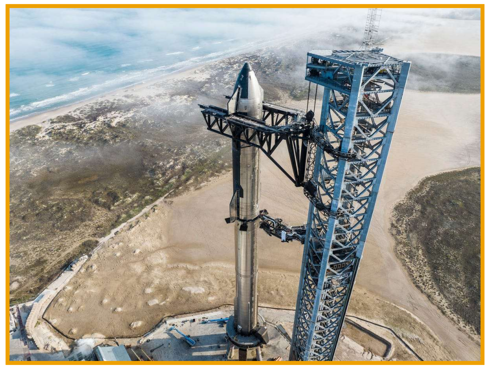
To be presented with page 15 of the session.

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?



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To be presented with page 15 of the session.

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

To be presented with page 15 of the session.

- “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 slide 39).
- Show photos / videos.”

The Astronaut Egg Experiment

Your mission is to launch an 'Astronaut Egg' into Space, landing it safely in one piece.

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To be presented with page 16 of the session.

"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 Water Rokit 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.

The Astronaut Egg Experiment

How NASA prepares for a mission

Before a mission commences at NASA, the team will agree on their mission objective.

At the end of the mission, they assess what parts of the mission were successful, and what could be improved for next time.

Adopt this method when experimenting:

Test/Measure/Improve/Optimise

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To be presented with page 16 of the session.

"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?

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To be presented with page 17 of the session.

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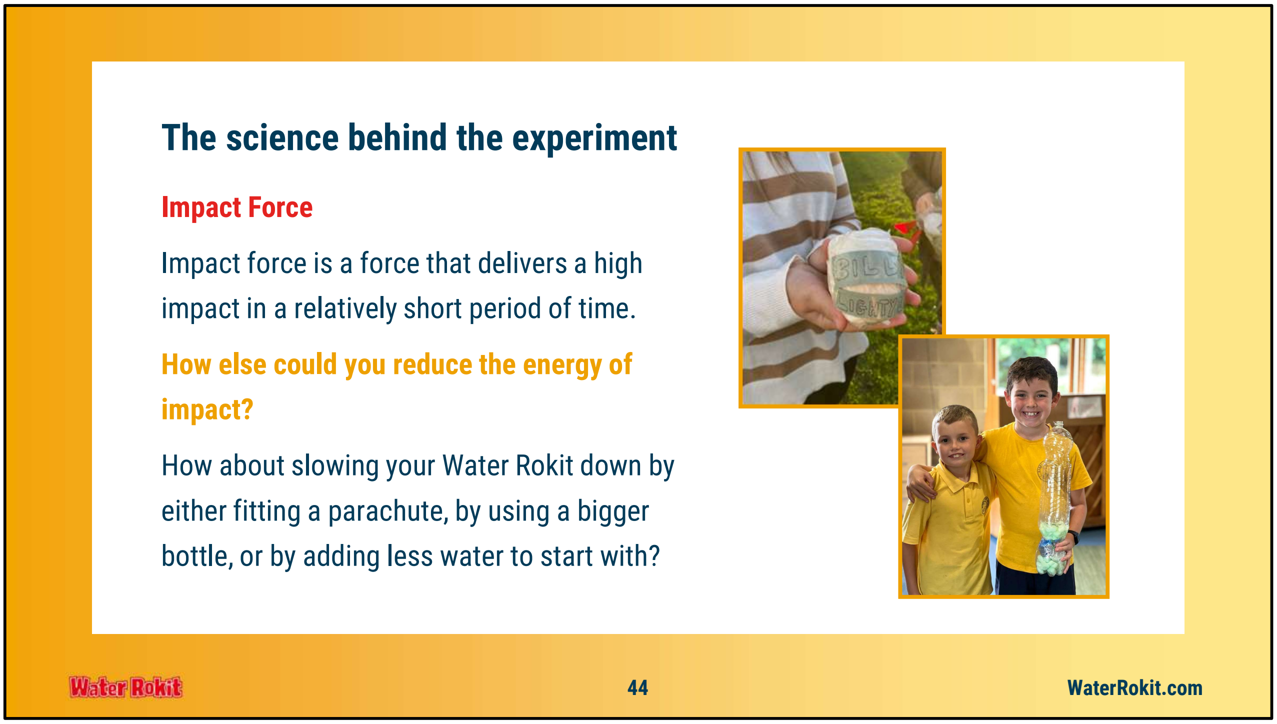

To be presented with page 18 of the session.

"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 and Astronaut Egg hit the ground, there will be an **‘impact force’** to the ground, and the ground will have **‘an equal and opposite reaction’.**

The dropped egg will **absorb the forces** from the collision upon landing and react.

Packing the egg in soft protective materials means that the energy will be absorbed by the material.

To be presented with page 19 of the session.

“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!)”