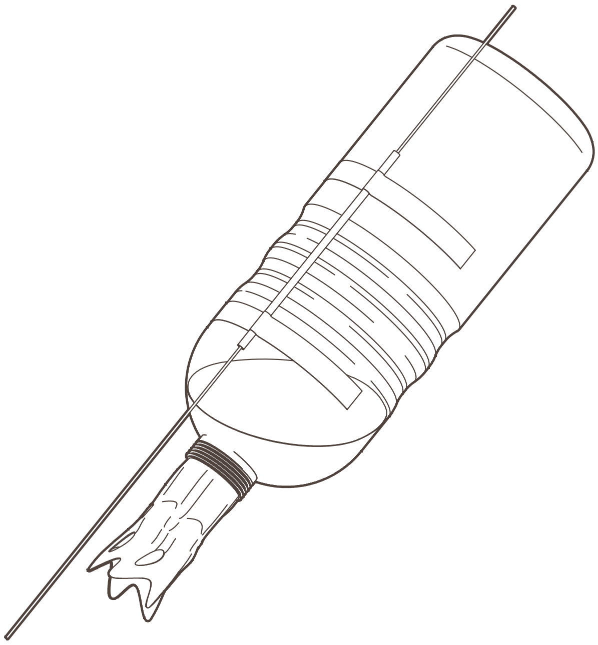


ROCKET WORKSHEET

GETTING STARTED

5-10m

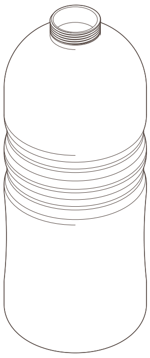
Rockets are the vehicles that allow humans to explore outer space and may someday even take us as far as Mars!

To escape Earth's gravity and make it into space, rockets can accelerate to incredible speeds of 15,000 miles per hour in as little as eight minutes.

This session will teach you how to design, build and launch two different types of rockets that can both take off at great speeds.

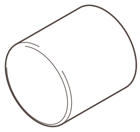
OUTDOOR ROCKET

YOU WILL NEED

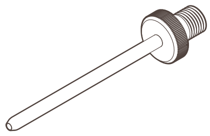


Plastic Bottle
1

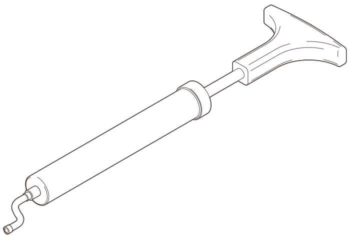
String
1 Reel



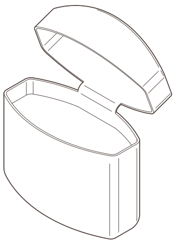
Cork
1



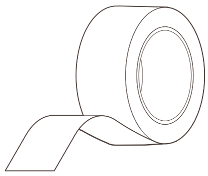
Ball Pump Needle
1



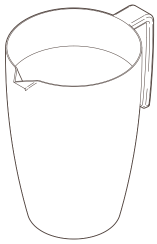
Pump
1



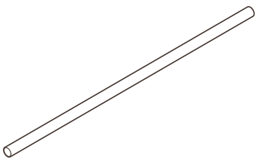
Petroleum Jelly
1



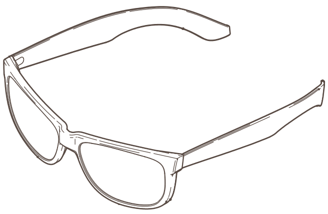
Tape
20cm



Jug of Water
1



Straw
1



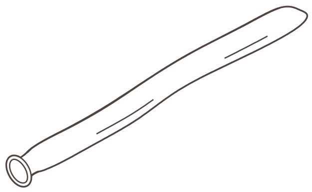
Safety Glasses
1

DID YOU KNOW?

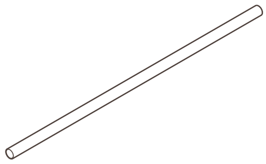
In order to burst through Earth's gravity, a rocket must be travelling at speeds of 7 miles per second.

INDOOR ROCKET

YOU WILL NEED

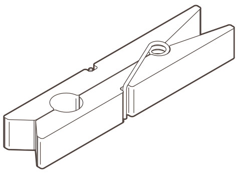


Balloon
1

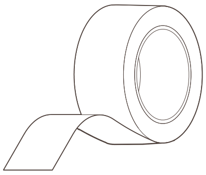


Straw
1

String
1



Peg
1



Tape
20cm

VOCABULARY

Friction - Is a force that acts between two objects that are in contact with one another. It slows or stops movement between the two surfaces that are touching.

Pressure - Is a way of measuring how much force is acting over an area. Concentrating a force into a small space increases pressure, therefore the force can do more than it would if it were spread out.

Potential Energy - The stored energy an object has because of its position or state.

Aerodynamics - The study of how air moves around a solid object. The more aerodynamic a flying object is, the better it will fly.

Drag - A force that tends to slow the movement of an object through a liquid or gas.

Stability - To fly a predictable flight path.

Acceleration - The change in speed of an object.

Thrust - A force that pushes an object forward.

WARM-UP ACTIVITIES

A

5-10m

Whether flying a small model rocket or launching a giant space shuttle into space, the principles of how rockets work are the same.

Consider and investigate how Isaac Newton's laws of motion can be applied to launching rockets:

- Newton's 1st Law: An object at rest will remain at rest unless acted on by an unbalanced force.
- Newton's 3rd Law: Every action has an equal and opposite reaction.

These laws are the foundation of all rocket science. Understanding these laws will help you to engineer rockets that can fly further and at greater speeds.

B

10-15m

Rocket aerodynamics is the study of how air flows over a rocket and how this affects drag and stability. Rockets are designed to minimise any drag (air resistance) and to provide stability and control.

Investigate the shapes of rockets that have been sent into space such as:

- SpaceX
- Apollo
- Delta
- Ariane
- Saturn

Using your research, design a rocket body shape that will minimise drag and maintain stability. You could, for example, add some additional design features to your bottle or balloon such as a nose cone or fins.

MAIN CHALLENGE

30-40m

The mighty rockets exploring space today are the results of more than 2000 years of invention, experimentation and discovery.

Building your own rocket is a great way to start to understand the principles behind rocket science that underpin the most complex of space missions.

Before you begin this activity, you will need to decide whether to work indoors or out.

The first set of instructions build a rocket that needs an open space and something secure to tie either end of your string to. If you do not have access to this kind of space, we suggest you try building the second rocket, which is safe to do with less available space, or indoors.

Both builds are great fun and demonstrate the principles of rocket science, which are explained in more detail below.

Every time an engineer is faced with a problem, they approach it using the Engineering Design Process.

Ask - What's the problem?

Imagine - Choose a solution.

Plan - Design and choose materials.

Create - Make it.

Test - Test your creation.

Improve - Redesign as needed.

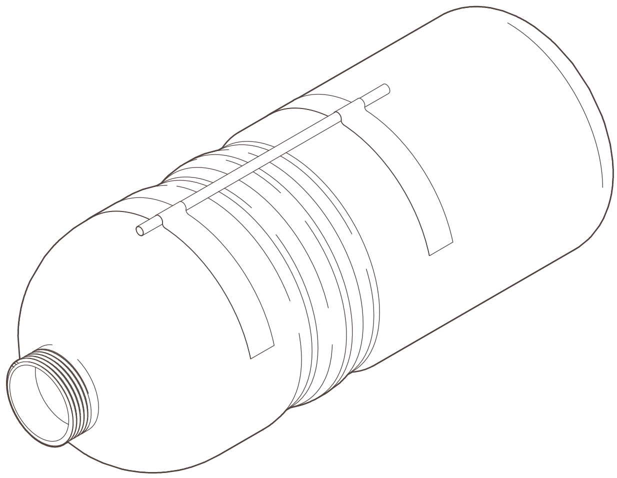
Using this design process, see if you can build rockets which fly faster and further. Good luck!

BUILDING THE OUTDOOR ROCKET

Follow these steps to build the outdoor rocket project!

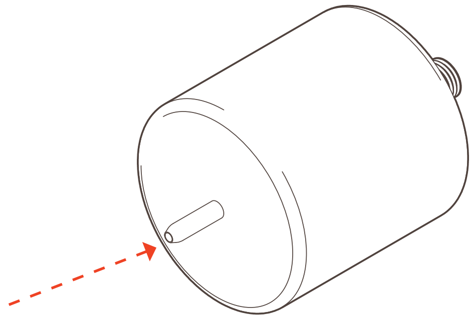
A

To begin, hold the straw lengthways against the straight edge of the bottle. Secure it very tightly with adhesive tape to make sure it does not bend.



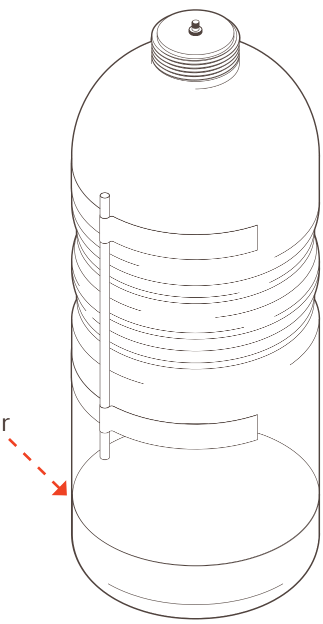
B

Trim the cork so it is shorter than the length of the ball pump needle. Then, carefully pierce a hole in the cork and push the needle into the hole and right through. You may need help from an adult with this stage.



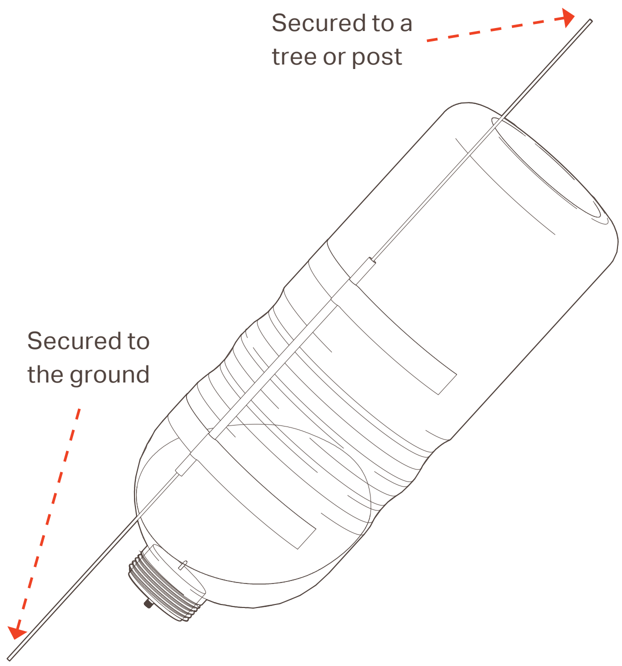
C

Next, pour 250ml of water into the bottle. Grease the cork with the petroleum jelly and push it firmly into the bottleneck so that the needle sticks out the top. Greasing the cork reduces the friction between the two surfaces, which will allow the cork to be pushed out of the bottleneck when the rocket takes off.



D

Now, take the string and tie one end to a tree or a tall post outside. Thread the string through the straw, starting at the bottom of the bottle. Secure the loose end of the string very firmly near the ground.

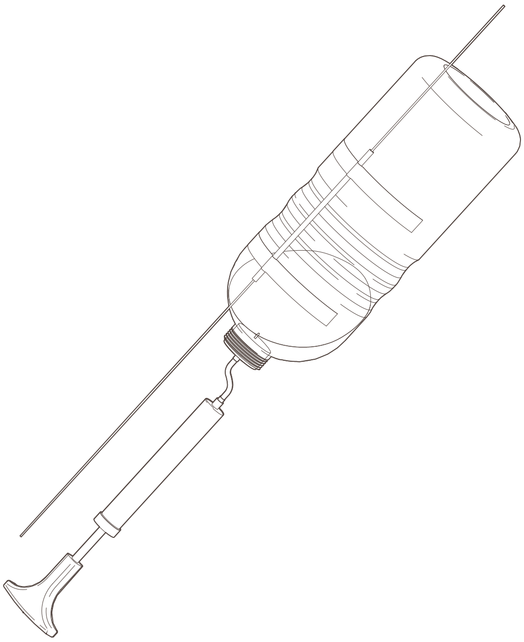


E

You are now ready to commence lift-off!

Before you do, check that the base of the bottle is pointing upwards, at about 45º. Also, check that the water is covering the neck of the bottle. If not, remove the cork, add a little water to the bottle, then replace the cork in the bottle neck.

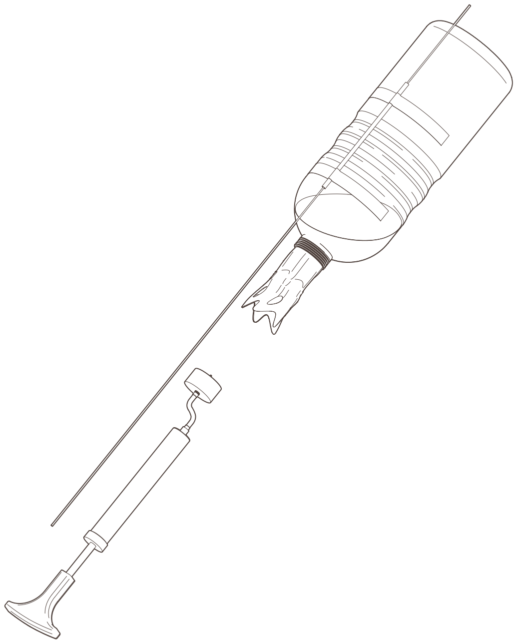
Finally, attach the pump to the needle. The pump will be used to pressurise the water, in order to produce a spray. It is this spray that creates the thrust to drive the rocket upwards.



F

At this point, we suggest you put on safety glasses to protect your eyes from any flying debris.

Then, begin pumping and be ready for the water to spray out of the rocket when it takes off!



DID YOU KNOW?

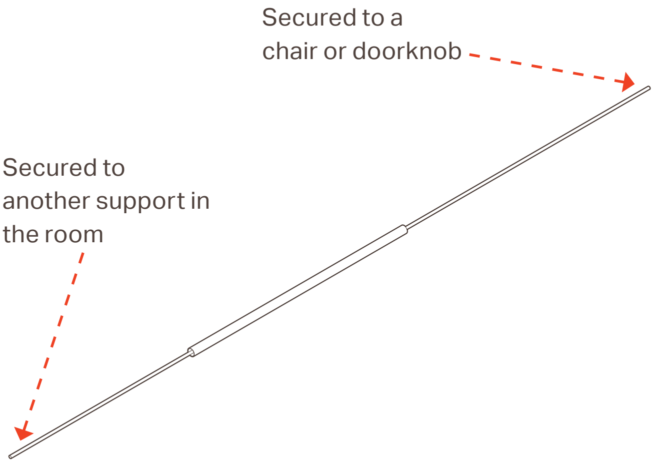
In April 1961, Russian cosmonaut, Yuri Gagarin, became the first human in space. He blasted off in a rocket, circled the Earth for 108 minutes, re-entered the Earth's atmosphere, ejected from the spacecraft and parachuted to the ground.

BUILDING THE INDOOR ROCKET

If you are working indoors, you can follow these instructions to create a rocket without the risk of getting wet!

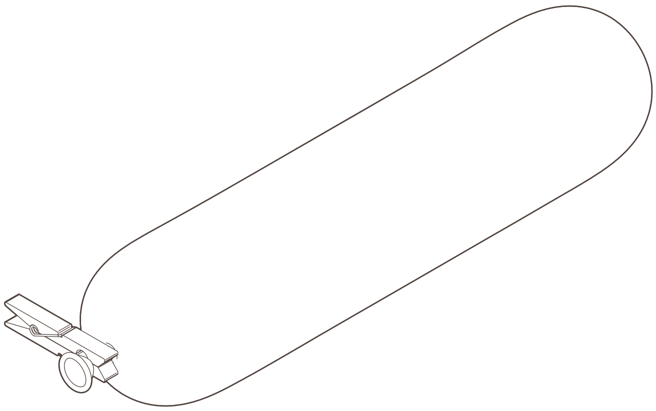
A

First, tie one end of the string to a chair, doorknob, or other support. Then, thread the other end of the string through the straw. Pull the string tight and tie it to another support in the room.



B

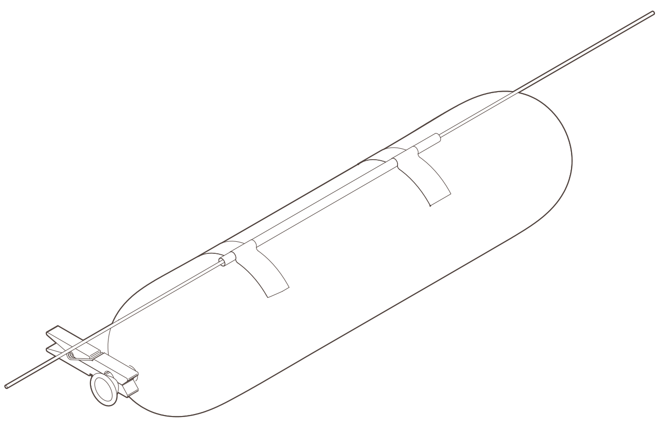
Next, blow up the balloon (but do not tie it). Pinch the end of the balloon and secure it with a peg. Trapping the air inside of the balloon creates potential energy, ready to power the rocket when the peg is removed and the air is pushed out.



C

Finally, tape the balloon to the straw. Now you are ready for launch!

Remove the peg and watch as the air escapes and creates the thrust needed to accelerate the rocket across the room.



ROCKETS
FORCES IN MOTION

KS2/3 UNDERSTAND THE SCIENCE

10-15m

Newton's Laws Applied to Rocket Science

Newton's laws help us understand how forces get objects, such as rockets, moving.

Newton's 1st Law: An object at rest will remain at rest unless acted on by an unbalanced force.

When a rocket is sitting on the launch pad, not moving, two forces are acting on it:

- Weight - the force due to gravity pulling the rocket downwards towards the centre of the Earth.
- Support Force - the ground pushing back with an equal force to the weight of the rocket.

These forces are balanced. This means that the force pulling it downwards is equal to the opposing force pushing it upwards.

For an object to start moving, the forces must be unbalanced. This means that the forces pushing an object in one direction are greater than the forces pushing it in the opposite direction.

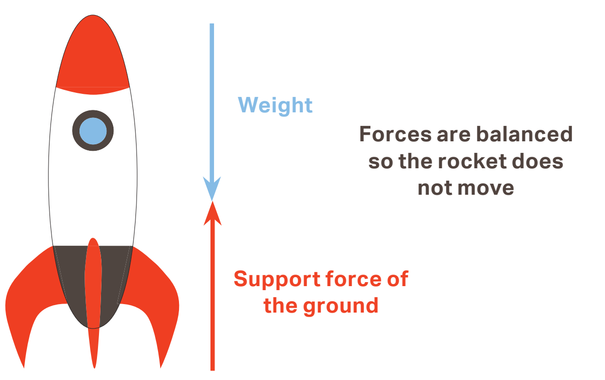
There are two forces acting on a rocket at the moment of lift-off:

- Thrust - pushes the rocket upwards by pushing gases downwards in the opposite direction.
- Weight - the force of gravity pulling the rocket downwards towards the centre of the Earth.

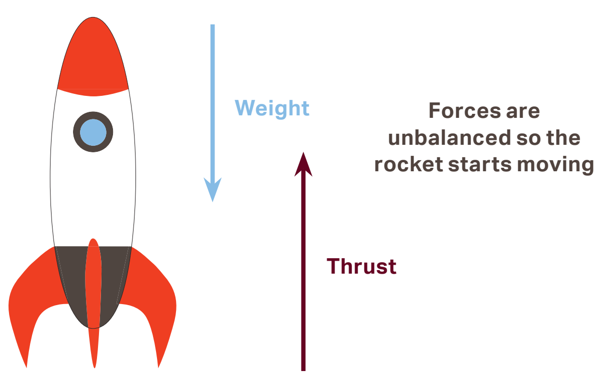
As the speed of the rocket increases, there is a third force of drag (or air resistance) that begins to act. Drag works in the opposite direction to thrust, therefore the thrust must be greater than the weight plus the drag for the rocket to continue accelerating.

In the model rockets created in this project, the principles of balanced and unbalanced forces are exactly the same as in real space rockets, the only difference is how the thrust force is created.

Forces acting on the rocket before launch



Forces acting on the rocket during take off

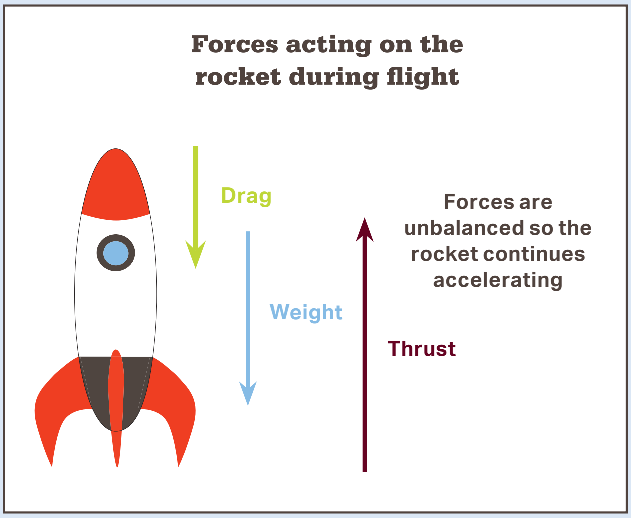


The force created by thrust can be explained using Newton's Third Law:

Newton's 3rd Law: For every action, there is an equal and opposite reaction.

In a space rocket, burning fuel creates a push on the front of the rocket pushing it forward (the action). This creates an equal and opposite push on the exhaust as the gases push it backwards (the reaction).

In the balloon rocket, the air trapped inside the balloon pushes out the open end, causing the balloon to move forward. The force of the air escaping is the action; the movement of the balloon forward is the reaction.



In the water rocket, the force of the air (and water) as it rushes out of the nozzle is the action, which creates an equal and opposite reaction force, propelling the rocket upward. Having water inside the bottle, rather than just air, creates more thrust because water is heavier than air. This means, it takes more force to throw water downward compared to air. As the action force is greater when water is involved, the reaction force also has to be greater.

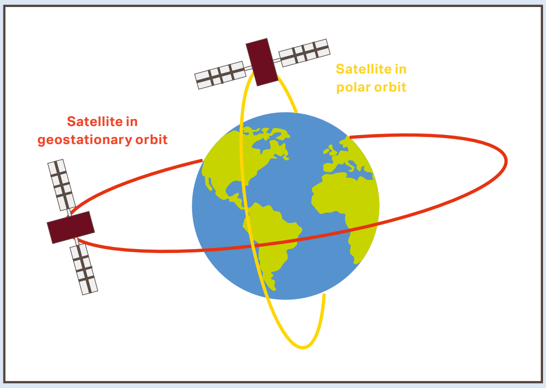
KS3/4 DEEPER LEARNING

10-15m

Satellites

Rockets are used to launch satellites into space. Their powerful engines allow them to take off at incredible speeds, placing the satellites into the correct orbit. It is gravity that provides the force needed to maintain the stable orbit of satellites, as they make their journey around our planet.

Around the Earth, there are currently a few hundred satellites working, but thousands of unused satellites and satellite fragments also orbit our planet as space debris. The largest satellite is the International Space Station, which usually has a crew of six astronauts on board.



Satellites are used for many purposes, such as monitoring and sending information back to Earth about the weather, connecting our mobile phones so we can communicate, and even allow one country to spy on another! Satellites travel in one of two different orbits:

- Polar orbits
- Geostationary orbits

Polar orbits take the satellites over the Earth's poles. The satellites travel very close to the Earth (as low as 200km above sea level), so they must travel at very high speeds (nearly 8,000m/s).

Geostationary satellites take 24 hours to orbit the Earth, so the satellite appears to remain in the same part of the sky when viewed from the ground. These orbits are much higher than polar orbits (typically 36,000km) so the satellites travel more slowly (around 3km/s).

Each satellite is placed in the best orbit to carry out its mission. For example, Earth observation satellites are usually placed in polar orbits. As the Earth spins beneath them, the satellites can look directly down and study the entire planet over a few days. This allows them to obtain detailed views of the planet's surface.

Weather and communications satellites often appear to 'hover' above the same part of the Earth 24 hours a day. This is made possible by placing them in geostationary orbits. They keep pace with the Earth's spin, so they are always looking down on the same places.

QUIZ

15-20m

At what point in a rocket launch are the forces balanced?

....

....

What is thrust?

....

....

Why does the bottle rocket cork need to be greased?

....

....

What type of energy is created by trapping the air inside of the balloon?

....

....

Which force begins acting on the rocket as it accelerates through the air?

....

....

QUIZ

Who was the first man in space?

....

....

What is Newton's Third Law of Motion?

....

....

How does the water in the bottle help the rocket create more thrust?

....

....

Name some of the purposes of satellites.

....

....

Which type of orbit might you expect a communications satellite to be put in?

....

....