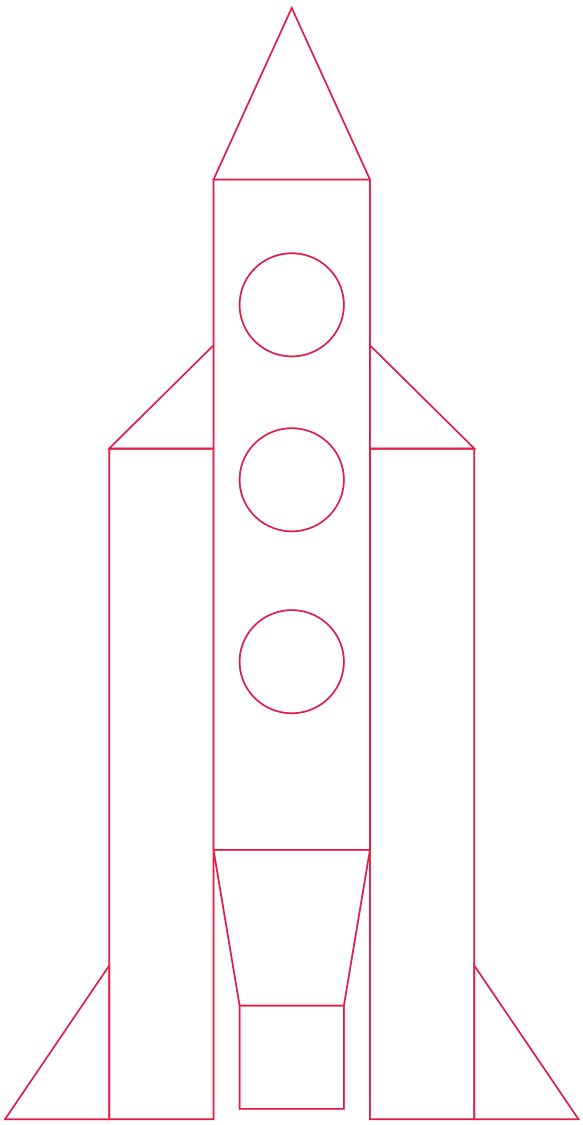
teach with space

→ UP, UP, UP!

Build and launch your own rocket



European Space Agency

→ BACKGROUND

Why do we need rockets?

On Earth, there is a force that continuously pulls us down towards the ground. We are so used to this force that we do not even notice it anymore. But when we jump, we always fall down again because of this force. This force is called **gravity***.

If an astronaut wanted to escape Earth's gravity, he would have to jump very, very high and very, very fast, otherwise he would fall back down to Earth (as he does in Figure A1, jumps 1 and 2).

But, if the astronaut could jump with the right direction and speed, he would be able to counteract the Earth's strong gravity. With this specific direction and speed, instead of falling directly to the ground, he would fall towards Earth, but miss the planet; as a result he would fall around the Earth and enter orbit* (Figure A1, jump 3). The astronauts on the International Space Station and satellites observing the Earth are also in **orbit***.

Figure A1

↑ The force of gravity pulls us down to the ground continuously. To escape it, astronauts would need to jump with a very high speed and specific direction.

No astronaut can jump fast enough to escape Earth's gravitational pull! That is why scientists have invented rockets.

***Gravity**: The force of attraction felt between two objects, in this case the Earth and us.
Orbit: The motion of an object in a circular or elliptical path around another object.

→ ACTIVITY 1: GET ME OFF THIS PLANET!

Rockets are amazing machines that can be used to explore space. They take humans, satellites, and spacecraft where they need to go. In this activity you will carry out an investigation into rockets.

Equipment

- 1 pair of scissors
- Glue
- 3 ESA rocket 'stickers'

Exercise

1. In the boxes below, stick the rocket 'stickers' provided by your teacher.

2. Explain why you think the rockets have different sizes.

3. Use the internet to look for information about one of the rockets. Complete Table A1 with its main characteristics.

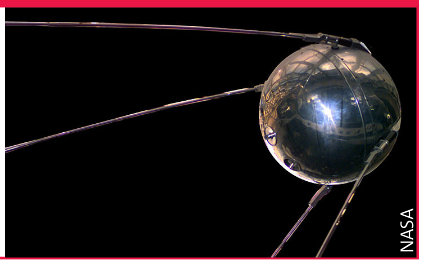
Table A1

Main data	Rocket name: ______________________
Height	
Diameter	
Lift-off mass	
Maximum payload mass	
Missions it has been used for	

↑ Rocket characteristics

Did you know?

The first satellite to be launched into space was Sputnik, in October 1957, and the first man to go to space was Yuri Gagarin, in April 1961. Since then, over 550 astronauts and cosmonauts have been to space and thousands of artificial (man-made) satellites orbit the Earth. Each of these have been placed into orbit either directly or indirectly by a rocket.



→ ACTIVITY 2: AIR FOR THE ROCKET (I)

In this activity you are going to build a paper rocket that will fly, using a straw as a launcher. You will work like a real scientist to design a rocket and test it through the different development stages.

Equipment

- 1 A4 sheet of paper
- 1 straw
- 1 pencil
- 1 pair of scissors
- Sticky tape
- Template for the fins

Health and safety

- Launch the rockets in an open area.
- Launch only in a safe area, as identified by your teacher.
- Do not launch the rockets in the direction of other people.

Exercise

1. Follow instructions I to IV of Figure A2 to build the body of your rocket:

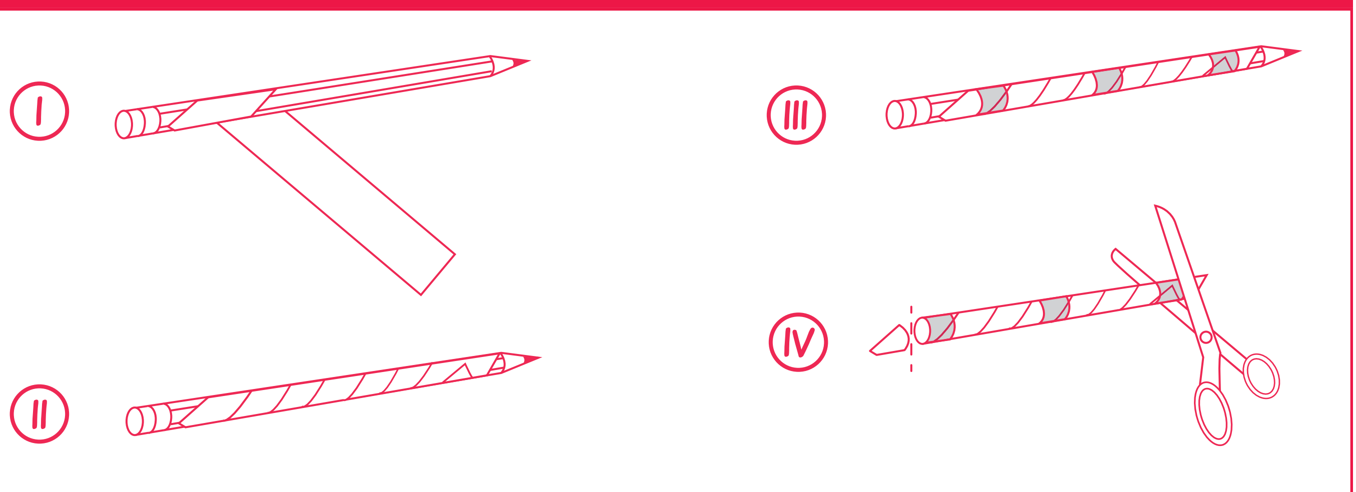
   I. Cut a strip 5 cm wide, from the long side of an A4 sheet of paper. Starting at one end of the pencil, hold the paper at an angle of approximately 45° to the pencil.

   II. Roll the paper strip around the pencil fairly tightly until you get to the other end.

   III. Tape the tube closed so it does not unravel and remove the pencil.

   IV. Cut off both ends of the tube.

Figure A2



↑ Building the body of your rocket.

2. Insert the straw into one of the open ends.

3. Before launching your rocket, think about how it will behave in the air and how far it is going to fly? Write down your predictions in Table A2 in the discussion section on the next page.

4. Launch your rocket by blowing hard into the straw. Was your launch successful? Write down your observations in Table A2.

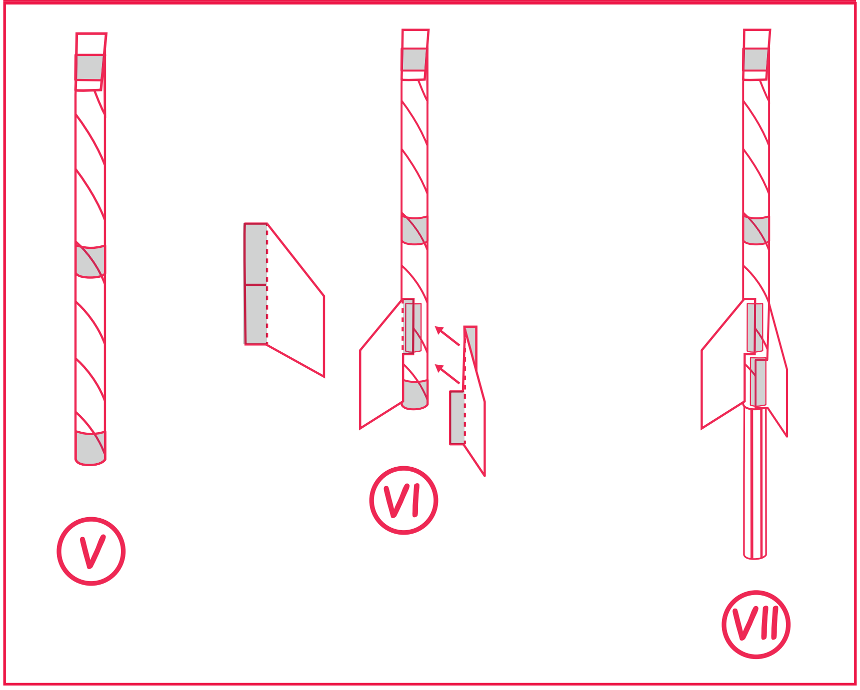
5. Continue the construction by following the next steps, V to VIII (Figure A3):

V. Fold over the upper end of the rocket so that it forms a point and tape it.

VI. Cut out the fins from the template and tape them to the rocket.

VII. Insert the straw into the open end. Before launching the rocket again, consider what trajectory you expect to observe. How far do you think your rocket is going to fly? Write down your predictions in Table A2 on the next page.

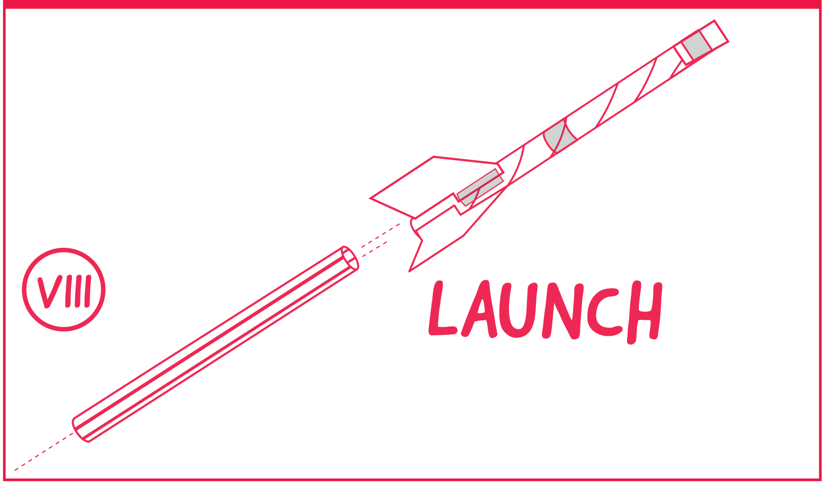
Figure A3



↑ Developing your paper rocket.

VIII. Repeat the rocket launch by blowing hard into the straw. Observe what happens and write down your observations in Table A2.

Figure A4



↑ Launching your paper rocket

Discussion

1. Complete Table A2 with your predictions and observations for each rocket launch.

Table A2

	Launch 1	Launch 2
Predictions		
Observations		

↑ Your predictions and observations.

2. Compare your observations from Launch 1 and Launch 2. Describe and explain any differences between the two launches

3. Based on your observations, explain what you think is necessary to give a rocket in order to launch it into space. How is launching a real rocket different to launching a paper rocket?

Did you know?

To get into space, rockets need to travel at very high speeds. The required speed depends on the height that the rocket needs to reach. For example, the International Space Station (ISS) is about 400 km above the surface of the Earth. To supply the ISS, a rocket must reach a speed of about 28 000 km/h, or nearly 8 km/s, to compensate for the pull of Earth's gravity. The Soyuz rocket in the picture transports astronauts to the International Space Station.


NASA

→ ACTIVITY 3: AIR FOR THE ROCKET (II)

In this activity you will build a paper rocket then launch it using a plastic water bottle and 3D launch elbow. You will also try to find out how the launch angle affects a rocket's **trajectory***.

Equipment

- 2 A4 sheets of paper
- Nose and fins template
- 1 500 ml plastic water bottle.
- 1 3D printed launch elbow
- 1 protractor
- 1 pair of scissors
- Sticky tape
- Long measuring tape

Health and safety

- Launch the rockets in an open area.
- Launch only in a safe area, as identified by your teacher.
- Do not launch the rockets in the direction of other people.
- Wear safety goggles to prevent eye injury during launch.

Exercise

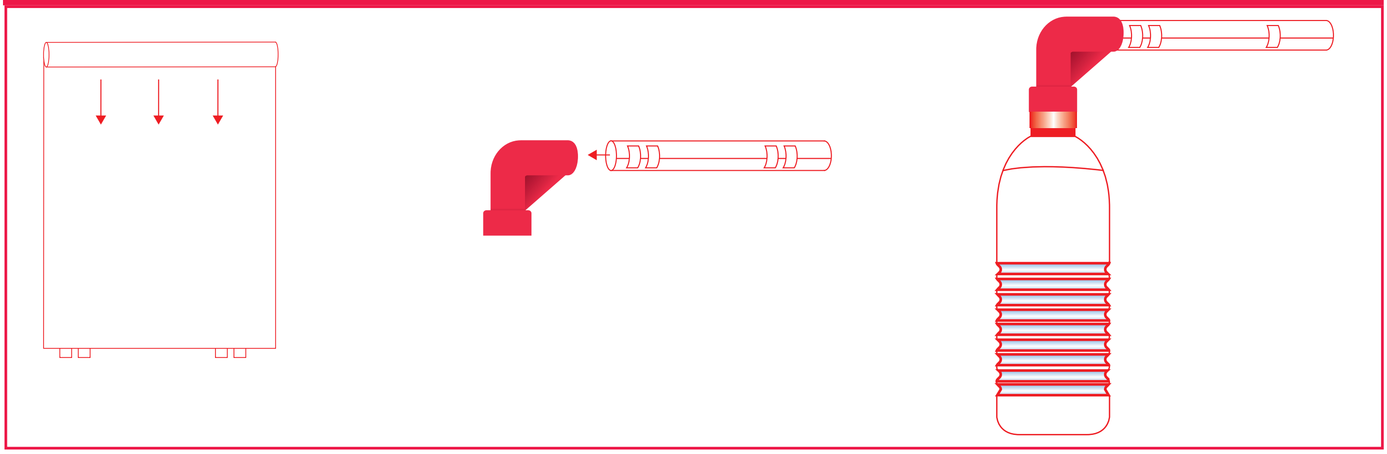
Step 1: Assemble your **launch platform** by following the instructions below.

I. Roll up one A4 piece of paper into a cylinder with a length of 21 cm and a diameter of approximately 2 cm, or wide enough so that it fits just inside the launch elbow. Tape the paper in such a way that it will be in a pipe shape.

II. Insert the paper pipe into the launch elbow as shown in Figure A5. Tape the paper pipe to the launch elbow.

III. Screw the water bottle on to the other side of the launch elbow. Your launch platform is ready.

Figure A5



↑ Assembling your paper rocket launch platform.

Step 2: To build your **rocket**, follow the instructions below.

I. Roll one A4 piece of paper into a cylinder with a diameter of approximately 2.5 cm and a length of 29 cm (Figure A6).

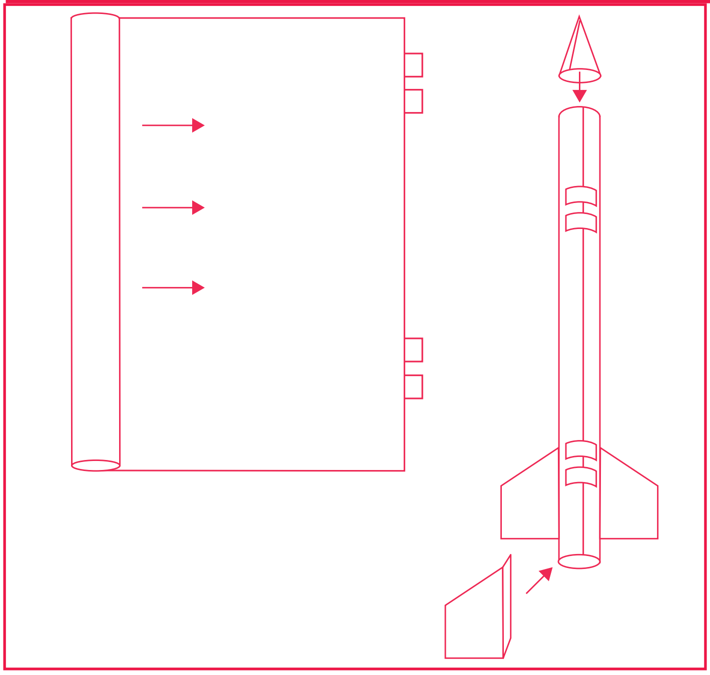
II. Apply tape to hold this pipe shape. This is going to be the body of your rocket. Make sure the launch platform pipe that you made in Step 1 fits into the rocket.

III. Seal one of the open ends of the cylinder with tape, making the front of the rocket.

IV. Create the nose of the rocket. One possible way of making a nose cone is to cut out a circle of approximately 8 cm diameter. Cut out a quarter segment of the circle. Bring the ends of the circle together, wrap around, and seal with tape. Make sure there are no holes!

V. Fasten the cone to one of the open ends of the rocket body with tape.

Figure A6



↑ Building a paper rocket.

VI. Add fins to your rocket and it is ready to launch! Make sure that your rocket is well taped and don't forget to give it a name!

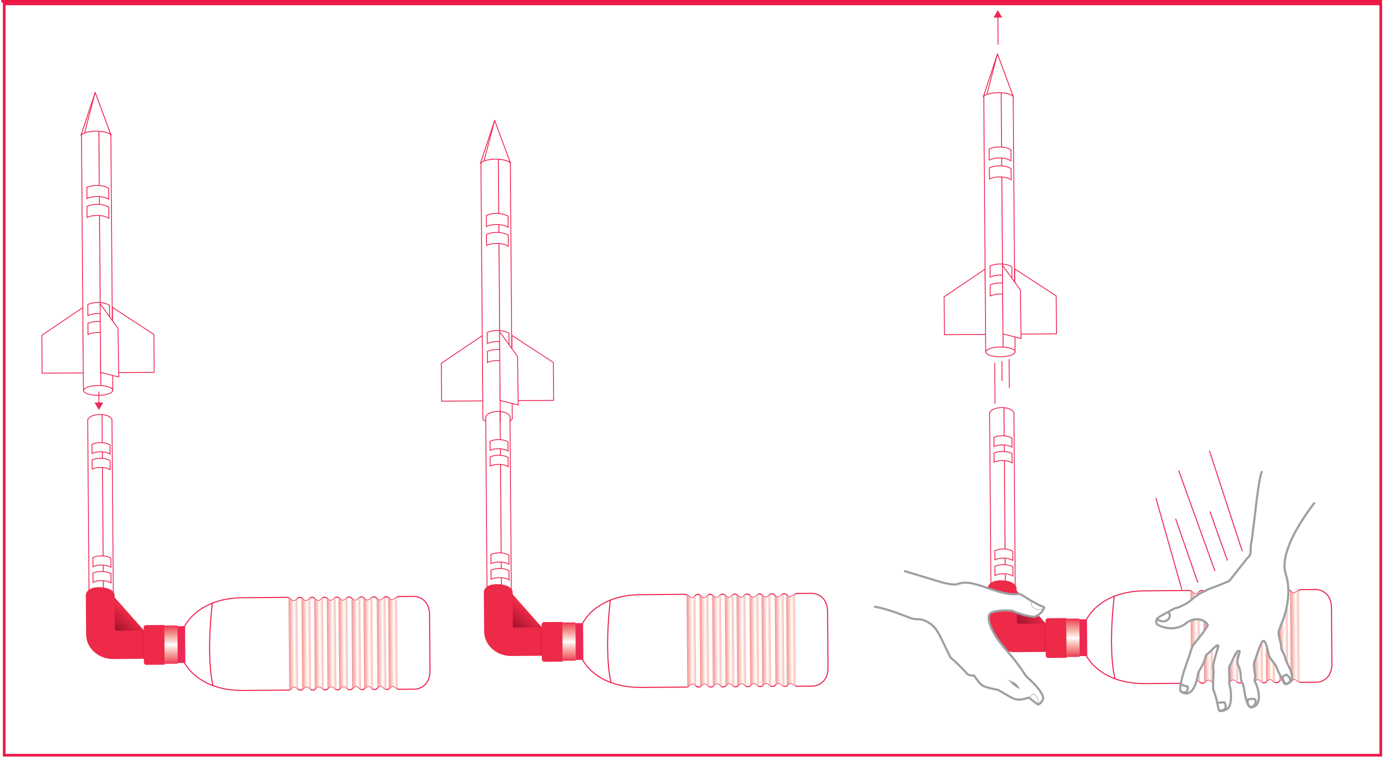
3. Place your rocket onto the paper launch platform pipe (Figure A7).

4. Place the rocket launch system and the rocket on the floor.

5. Decide what angle you want to launch your rocket at. Measure this angle using a protractor and hold the launch platform firmly at this angle.

6. To launch the rocket put one of your hands on the 3D launch elbow (to help keep the launch angle) and put your other hand on the centre of the bottle. Press hard on the bottle to launch your rocket (Figure A7).

Figure A7



↑ Launching your paper rocket.

7. Observe the flight path of your rocket.

8. Measure the horizontal distance that your rocket travelled from launch to landing site.

9. Carry out one more launch under the same conditions (same launch angle and same pressing force on the water bottle) and measure the distance travelled.

10. Repeat the experiment using different launch angles (see Table A3 in the discussion section below) and measure the distances travelled.

Discussion

1. Complete the table below with the distances travelled by the rocket. Calculate the average distance for the different launch angles.

Table A3

Launch angle (°)	Distance (metres) Launch 1	Distance (metres) Launch 1	Distance (metres) Average
75			
60			
45			
30			

↑ Distance travelled at different launch angles.

2. From your results explain how the launch angle affects the rocket's trajectory.

3. Identify two possible sources of uncertainty when using this method to launch rockets.

Follow-up activity

1. Describe what changes you think you would observe in the trajectory of the rocket if you pressed the water bottle with more strength (more energy).

2. Repeat one of the launches to test your hypothesis. Compare the results. Was your hypothesis correct?

3. Write a conclusion for your follow-up experiment.

Did you know?

Getting into space is very expensive. Every time a rocket is used to launch a satellite or any other payload to space, many parts of the rocket fall into the ocean or burn up in the atmosphere. To reduce the cost, researchers are looking for ways to make rocket elements reusable. For that, the rockets need to be able to face the intense heat of re-entry into the atmosphere, which is caused by the friction between the speeding rocket and the air. ESA is developing and testing new technologies in order to build a new set of reusable rockets.

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The image on the right is an artist's impression of ESA's IXV Intermediate eXperimental Vehicle, which performed a full atmospheric re-entry and splashed down at a precise spot in the Pacific Ocean.

→ ACTIVITY 4: FUEL FOR THE ROCKET

When a rocket is launched, it burns about 500 000 kilograms of fuel in just a few minutes. In this activity, you are going to investigate the relationship between the amount of fuel in a rocket, and the distance that it travels.

Equipment

- 1 35mm white film canister
- Effervescent tablets (e.g. Alka-Seltzer®)
- Water
- Long measuring tape
- Sticky tape
- 1 pair of scissors
- 2 chairs
- 5 metres of fishing line
- 1 drinking straw
- 1 plastic cup

Health and safety

- Do not launch the rockets in the direction of other people.
- Wear safety goggles to prevent eye injury during launch.
- Do not lean over the rocket if it fails to launch, as it could launch at an unexpected moment.

Exercise

1. Plan an experiment using the materials provided, which will investigate the importance of fuel in a rocket. You should investigate how to propel a rocket using fuel, as well as looking into how the amount of fuel affects the distance that a rocket travels.
2. Discuss your plan with your teacher and peers. Make any necessary adjustments.
3. Prepare the experiment. For better results we suggest a horizontal launch.
4. Launch the 'rocket'. Record the amount of fuel used, and the distance that the rocket travels.
5. Present your conclusions to your teacher and peers. Explain the choices you have made and your results.

Did you know?

Europe's Ariane 5 rocket weighs 780 tonnes at lift-off. Most of this mass comes from fuel in the boosters, in the form of solid propellant and liquid hydrogen. Hydrogen is extremely easy to burn if oxygen is present, but it is very hard to store. To store it as a liquid, hydrogen must be kept at –253ºC, and needs an extremely large container. To get an idea of how cold this temperature compare it with the temperature at which water freezes: 0ºC!

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Activity concept developed by ESERO Portugal and ESERO Netherlands

The ESA Education Office welcomes feedback and comments
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