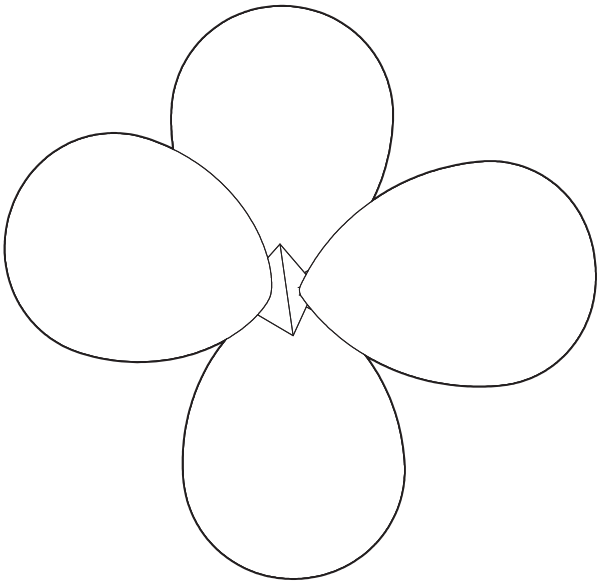


SPACE LANDER WORKSHEET

GETTING STARTED

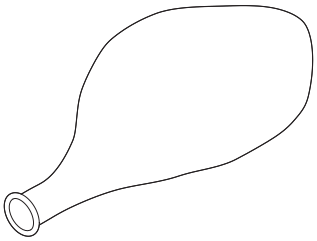
5-10m

For missions to Mars to be a success, cutting edge technologies and engineering solutions must be combined to ensure the safety of the equipment and astronauts who travel deep into our solar system.

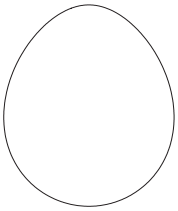
In this project, you will take on the role of a space engineer who must design and build a landing capsule for some very important but fragile equipment. In the testing phase, eggs will be used to represent the equipment that must be safely delivered to Mars.

Taking inspiration from the technology used in previous space missions, you will design a capsule that can protect the egg when it is dropped from a height. During the process, you will learn about the forces experienced by landing capsules and how you can engineer solutions to keep your egg from breaking on impact!

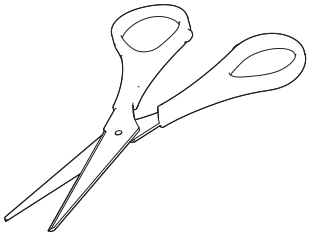
YOU WILL NEED



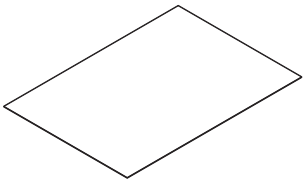
Balloons
4



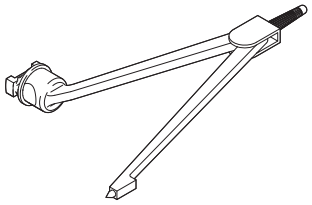
Eggs
3



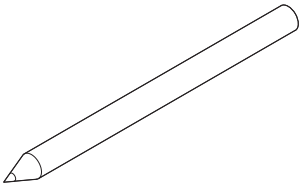
Scissors
1



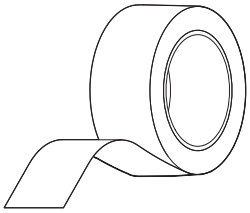
A4 craft card
3



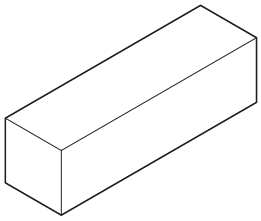
Compass
1



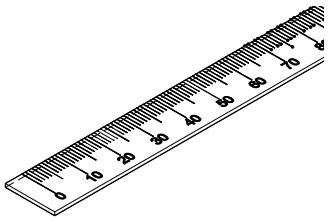
Pencil
1



Sticky tape
1



Rubber
1



Ruler
1

DID YOU KNOW?

Mars is home to Olympus Mons, the tallest mountain in the solar system.

VOCABULARY

Acceleration - The rate of change of the velocity of an object.

Gravity - A force of attraction that pulls together all matter.

Air Resistance - The frictional force that air exerts against a moving object.

Shock Absorber - A device used to dampen or lesson sudden, rapid motion.

Intersect - To cut or divide by passing through or across.

Arc - A section of a curve.

Equilateral Triangle - A triangle with three sides of equal length.

Net - The shape a 3D shape would make if it was opened out and flattened.

Tetrahedron - A flat-sided solid object with four triangular faces.

Compass - An instrument with two arms, one sharp and one with a pencil, that can be used to draw circles or arcs.

WARM-UP ACTIVITIES

A

5-10m

When an object falls towards the Earth it gets faster and faster. As it falls another force, air resistance, builds up to stop it moving as quickly. Air resistance is also increased if the object's surface area is greater. Some objects fall differently depending on how gravity and air resistance interact.

Make some observations of the following:

- Half fill one plastic bottle and leave another (the same size) empty. If dropped from the same height they will hit the ground at the same time.
- Take two sheets of paper – scrunch one up into a ball and leave the other flat. If dropped from the same height the flat piece of paper will fall to the ground more slowly than the scrunched-up ball.

These demonstrations show that any difference in speed between two objects that are dropped at the same time is solely due to the resistance provided by air molecules hitting on the objects as they fall. It is important to consider how gravity and air resistance will interact with the space lander, when you are engineering a safe landing.

B

10-15m

In 1976 NASA's spacecraft Viking 1 first landed on Mars, since then there have been a number of successful missions which have touched down on the planet's surface using a variety of different methods to ensure a safe landing.

Research to find out how NASA engineered a safe landing for these Mars Rovers:

July 1997 - Sojourner

January 2004 - Spirit and Opportunity

August 2012 - Curiosity

February 2021 - Perseverance

Investigating the landing systems that have been used in previous space missions, will give you inspiration for designing your own.

MAIN CHALLENGE

30-40m

Building this model is a great way to learn more about the forces experienced by landing spacecraft and the engineering behind keeping astronauts and equipment safe in space.

We have provided you with an example of how to build a Space Lander and suggested some materials you could use, but if you are feeling creative we encourage you to design your own!

Before you begin, you may like to collect a variety of different materials that are lightweight and change shape when they are compressed. This will give you plenty of options when choosing the best material to absorb the shock of the landing and protect the egg.

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 choose the most suitable materials and create the safest landing system for your egg. Good luck!

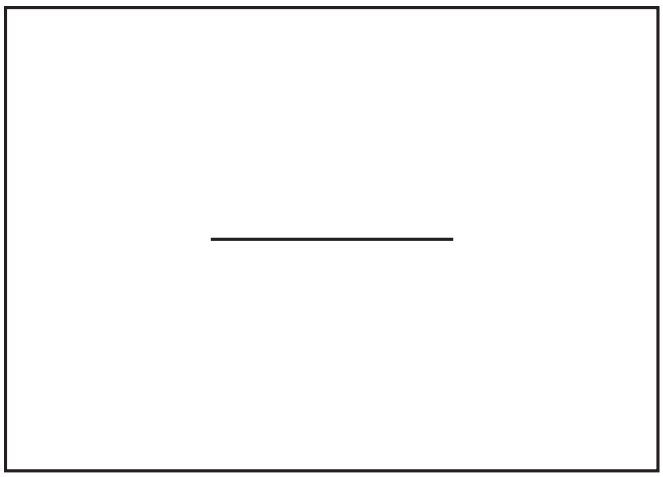
BUILDING THE SPACE LANDER

There are many ways to protect the egg inside of your landing capsule with the materials you have to hand, but if you are unsure where to start, here are the steps that we followed to build ours:

A

To create the pyramid-shaped landing capsule that holds the egg in place, you will first need to draw the net of a tetrahedron.

Begin by folding a thin sheet of A4 card in half horizontally and drawing an 11cm long line along the fold using your ruler to make sure it is straight.

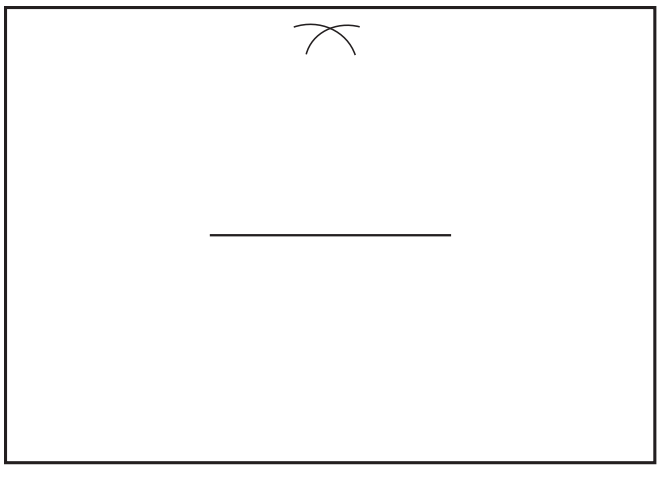


B

Open your compass to 11cm and position the point on one end of the 11cm line. Draw an arc where the pencil meets the paper.

Repeat with your compass on the other end of the 11cm line so that the two arcs intersect one another. This point will form the third corner of your equilateral triangle.

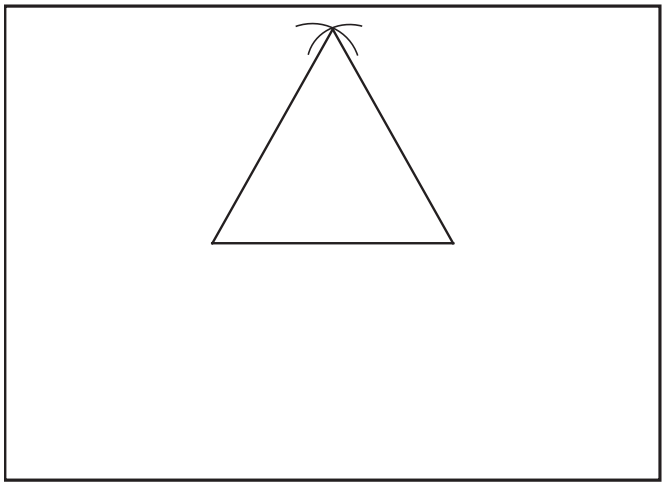
Connect the ends of the 11cm line with the point where the arcs intersect using your pencil and ruler.



C

Now, use the compass to draw three more identical triangular faces. This time draw longer arcs from each of the corners of the first triangle, these will form the flaps needed to stick the net together.

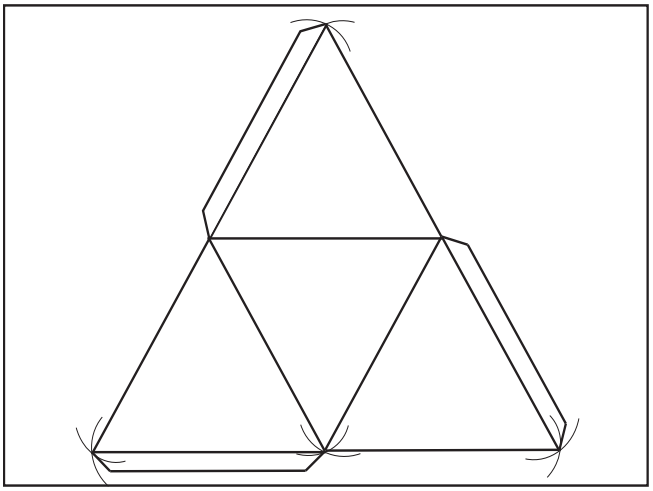
When you have drawn all 6 arcs around the central triangle, use your pencil and ruler to connect the points where the arcs intersect to the corners of the central triangle to make four identical equilateral triangular faces.



D

Leave 3 of the 6 tabs created by the compass arcs. Rub the rest out to complete your tetrahedron net. Then cut the net out carefully with scissors.

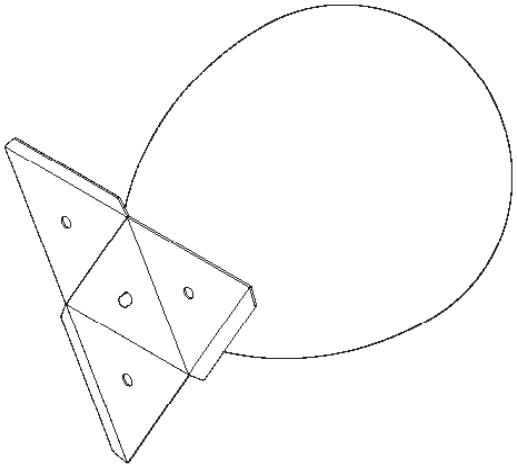
Fold along the lines of the middle triangle and the outer flaps. Finally, draw the edges of the net together and check that they meet precisely to make a strong pyramid capsule for your egg.



E

The shock created when the landing capsule hits the ground will be absorbed by balloon airbags. To attach the airbags to the pyramid, make a small hole in the centre of each triangular face with a sharp pencil.

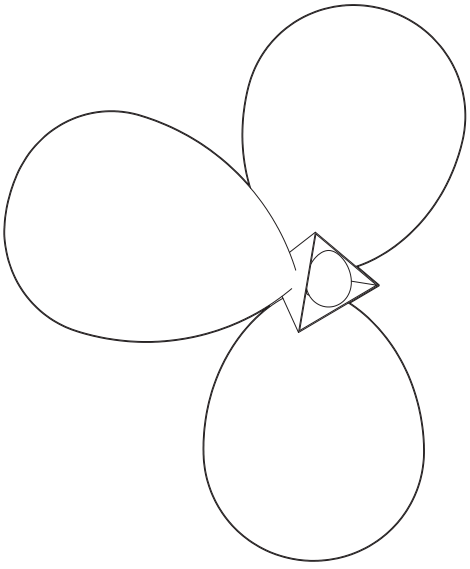
Inflate four balloons and tie a knot in each one. Push the knotted end through the holes and secure them in place with short lengths of sticky tape.



F

Carefully, place your egg inside of the pyramid landing capsule and secure the sides of the net using the flaps and some more sticky tape.

Your landing device is now ready for testing!

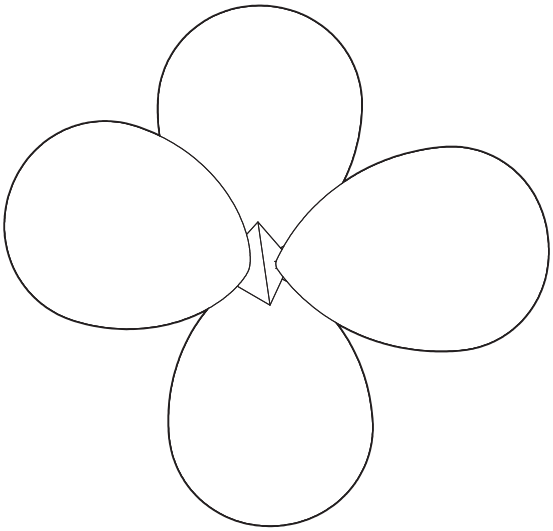


G

To test the landing device, prepare an area so that any broken egg can be easily cleaned up. You will also need to find a high point to drop your landing device from, that you can access safely. You may need to ask an adult for help at this stage.

When your landing area is prepared, drop your device. Then open the landing capsule to see whether your egg has been protected by the shock absorbers and survived the fall.

Good Luck!



CAUTION

If you handle raw eggs, make sure you wash your hands with warm soapy water.

DID YOU KNOW?

A spacecraft can be travelling at 12,000 miles per hour when it enters the atmosphere of Mars!

SPACE LANDER

SAFETY IN SPACE

10-15m

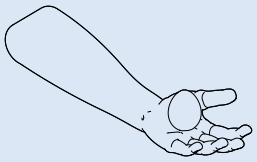
KS 2/3
UNDERSTAND THE SCIENCE

Understanding Issac Newton's laws of motion can help when engineering a solution for the space lander project.

1st Law – An object at rest will remain at rest unless acted on by an unbalanced force.

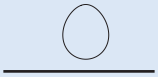
2nd Law- The acceleration of an object depends on the mass of the object and the forces applied.

3rd Law – For every action force, there is an equal and opposite reaction.



Newton's 1st law: If you hold an egg, the forces you are applying are equal and balanced, cancelling out the force of gravity. Therefore, it remains motionless in your hand. If you let go of the egg, gravity becomes an unbalanced force and causes the egg to fall to the ground.

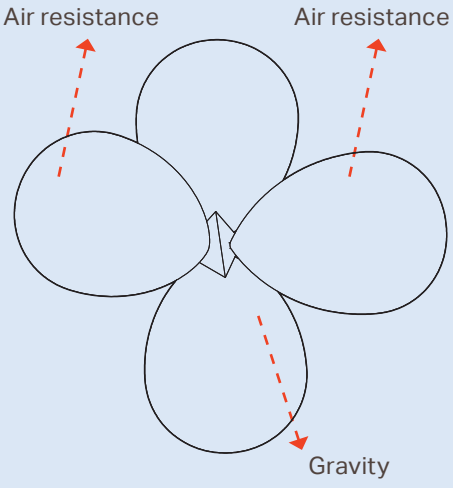
Newton's 2nd law: The egg is accelerating because gravity is pulling it towards the earth. How much it accelerates depends on the height from which it was dropped and the mass of the egg. Force increases with larger masses and higher heights.



Newton's 3rd Law - When the egg strikes the ground; the ground is returning the force from the egg with an equal and opposite reaction force. Usually, this force is so great it cracks the shell of the egg.

One way to prevent the egg from breaking is to increase the time it takes for the egg to come to a rest. Materials that change shape when compressed, such as sponges, springs and balloons, can absorb some of the force of impact. The change in shape increases the time it takes for the egg to stop by a few nanoseconds, therefore, decreasing the force the egg experiences when it hits the ground.

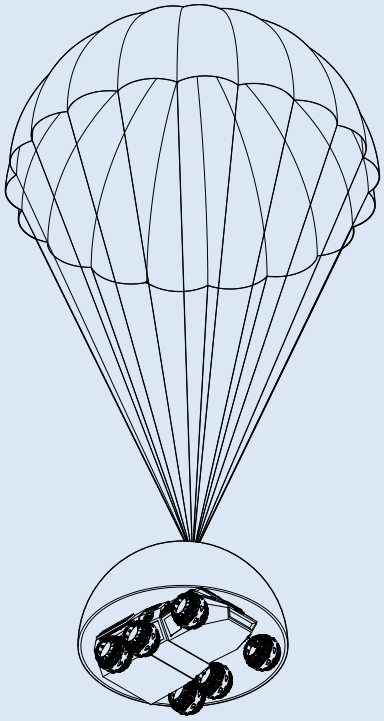
The egg will experience less force on impact if it can be slowed down before it lands. According to Newton's 2nd Law, to change the speed of the egg a force needs to be applied in the opposite direction to its motion. This can be achieved by adding landing bags, parachutes or other features which increase the surface area of the egg and therefore create additional drag or air resistance as it moves through the air.



KS 2/3
DEEPER LEARNING

Exploring Deeper Into Space

There have been a number of successful missions to date sending rovers to the surface of Mars, which have taught scientists a great deal about the geology and atmosphere of the Red Planet. However, there are still many unanswered questions about the fourth planet from the sun which can only be answered by having humans on the ground. Exploring further into the solar system creates a huge number of engineering challenges including how to design spacecraft that can deliver human cargo safely to the planet's surface.



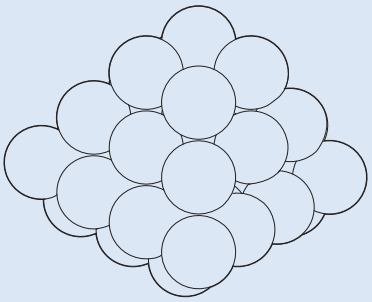
Landing Exploration Rovers On Mars

The spacecraft that carry the exploration rovers hurtle toward Mars at thousands of miles per hour! Before reaching the planet, they must slow down and then land gently to avoid damaging the incredibly expensive and delicate technology inside.

All capsules are fitted with a heat shield. Made from specially engineered materials they protect the capsule inside from the heat and friction experienced on entry into the Martian atmosphere.

Many capsules are fitted with a parachute to create friction from air resistance which slows the capsule down. However, even with the decelerating effect of a parachute, the capsule will still be falling at over 100 miles per hour, so the right system to land safely is needed!

NASA has engineered a variety of solutions to land their Mars Rovers safely:



- With a small- to midsize rover, a cushion of airbags can be used along with retro rockets. The capsule will impact the planet's surface at 30 miles an hour and bounce to a stop.

- With a large lander, retro rockets and landing legs can be used to reduce the speed of touch down to about six miles an hour.

- Or, with a large, heavy rover, a big jet pack can be used to slow down the landing to under two miles an hour. Then, gently lower it on cables to land on its wheels.

QUIZ

15-20m

Why do scientists want to visit Mars?

.....

.....

How have the conditions on Mars changed over time?

.....

.....

What are the properties of an equilateral triangle?

.....

.....

How many miles per hour can a spacecraft be travelling when it enters Mars' atmosphere?

.....

.....

What is Issac Newton's 3rd Law of Motion?

.....

.....

QUIZ

How many faces does a tetrahedron have?

.....

Why does an egg stay motionless in your hand before you drop it?

.....

.....

What properties should the materials used as shock absorbers for the landing capsule have?

.....

.....

What solutions have NASA previously engineered to land their Mars rovers safely?

.....

.....

What force is increased when a landing capsules parachute opens up?

.....

.....