Science Foundation Ireland
For what's next

Engineers Week Gravity

Classroom Resource Booklet

Engineers Week
24 Feb – 2 March 2018

Discover Primary Science and Maths
www.primaryscience.ie

Ireland esero

DPSM/ESERO
Framework for Inquiry

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THEME	Overall theme	
CURRICULUM	Strand:	
	Maths:	
	Strand Unit:	
	Curriculum Objectives:	
	Skills Development:	

ENGAGE

THE TRIGGER	WONDERING	EXPLORING

INVESTIGATE

STARTER QUESTION	PREDICTING	CONDUCTING THE INVESTIGATION	SHARING: INTERPRETING THE DATA / RESULTS

TAKE THE NEXT STEP

APPLYING LEARNING	MAKING CONNECTIONS	THOUGHTFUL ACTIONS

Considerations for inclusion

REFLECTION	

DPSM/ESERO
Framework for Inquiry

THEME	FALLING IN SPACE
CURRICULUM	**Strand: SESE:** Energy and Forces **Strand Unit:** Gravity **Curriculum Objectives:** Investigate falling objects; explore how falling objects may be slowed down…design and make a parachute. **Maths:** Measurement of mass, volume, time, temperatures. Record and display data. **Class:** Primary School students **Skills Development:** Investigating, designing and making.

ENGAGE

THE TRIGGER	WONDERING	EXPLORING
Show https://www.youtube.com/watch?v=FHtvDA0W34I Allow the students to watch clip of Felix Baumgartner's record freefall. Teacher background detail available on http://www.redbullstratos.com/the-mission/world-record-jump/	How did you feel watching the video? What did you see happening? What did you hear the commentator say? Why did Felix fall towards the Earth? Did you hear what speeds he was travelling at? Why did his speed not continue to increase? How does the parachute work to slow him down? Would a parachute work on the Moon? Is there gravity on the Moon? Is there air/atmosphere on the Moon?	Release different size, shape, mass objects from a height over the ground? What do you notice. All fall towards the ground at the same rate. Why do they go towards the Earth? If I did the same in Australia *(show on globe)* would it fall off into Space? No, it is also pulled towards the Earth. If I drop a full bottle of water and a half full one, which will reach the ground first? What did you notice about the speed of the bottles as they fell? Was it constant? See Galileo's experiment at Leaning Tower of Pisa. https://www.youtube.com/watch?v=cbC4sSEfEqw

INVESTIGATE

STARTER QUESTION	PREDICTING	CONDUCTING THE INVESTIGATION	SHARING: INTERPRETING THE DATA / RESULTS
DPSM Activity http://www.primaryscience.ie/media/pdfs/col/gravity_activity.pdf 1. Dropping thing of different masses from the same height – which reaches the ground first. What happens to their speed as they fall? 2. Dropping 2 balls of rolled up paper from the same height. What happens/ 3. Two sheets of paper – one rolled into a ball and leave the other one flat. Drop both from the same height.	Predictions must be based on a reason – they are not guesses. Students must be able to give the rationale for their predictions.	1. Both reach ground at same time. Speed increases as they fall 2. Both reach ground at same time. 3. Flat sheet falls more slowly. Why?	1. Gravitational force causes them to accelerate at the same rate (10m/s/s) 2. Gravitational force causes them to accelerate at the same rate (10m/s/s) 3. Air resistance acting upwards reduces the speed of the flat sheet. It creates an upward force which reduces the net force pulling the paper down so it does not have as great acceleration. This is how a parachute works *(refer back to Felix trigger video)* Now can you answer the question about using a parachute on the Moon? *(no atmosphere on the Moon so no upward force!)*

Considerations for inclusion

For children with special educational needs, it will be necessary to start at a much earlier level.

What happens if you let go of something you are holding?

Do all objects fall in the same direction? Why?

Does the nature of the object matter? Explore a range of objects – shape, size, material, feel, soft or hard.

Do they all fall the same way. Do any go up in the air?

All of the above question will have to be investigated by the children and assistance given in presenting their observations. This can involve drawings, pictures, verbal reports and models.

Why do I stay on the ground? What happens when I jump up into the air?

Get pupils to draw pictures showing where pulls are acting.

Make a model of gravity force - Earth pulling things towards it.

This is in conjunction with the many supports to be found at www.sess.ie

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INVESTIGATE - A SOFT LANDING

STARTER QUESTION	PREDICTING	CONDUCTING THE INVESTIGATION	SHARING: INTERPRETING THE DATA / RESULTS
ESERO Activity: http://esero.ie/wp-content/uploads/2015/01/80_A-soft-landing.pdf Put a raw egg in a plastic sandwich bag and seal the bag Drop it from a height of 2 metres What happens the egg? Play Air Resistance video https://www.youtube.com/watch?v=pqKFLPntcxsir	Is it possible to drop an egg from a height without breaking it? Why does the egg break? Does the egg need to be protected? Could the speed of the fall be reduced?	Could you make things safer for the egg and reduce the chances of it breaking?	Calculate the speed of their egg during its fall. Explain that if you know the distance an object travelled and the time it took to travel this distance, you can calculate the average speed of the object. Class discussion. Use your best parachute to slow the speed of the falling egg. Why do you want to slow down the egg as it falls? Can you land the egg on an exact target on the ground?

TAKE THE NEXT STEP

APPLYING LEARNING | MAKING CONNECTIONS | THOUGHTFUL ACTIONS

Design and make a parachute

Materials: Crepe paper, plastic bags, J-cloths, string, sellotape, plasticine people.

First design a parachute. Make a model using a 25cm. square of crepe paper. Fix strings onto the 4 corners.

Test if it is functional – does it slow down a falling plasticine person? Compare 2 'persons' falling from same height – one with parachute and one without.

(Take care if standing on chairs. Dropping over side of stairs is ideal)

If model works now proceed.

Now be prepared to expand the investigation.

Which is best material to make parachute with? What do we mean by "best"? Is it the one which slows down the fall the most? Is it the one which comes down straightest? You must decide.

What is the best shape of parachute– square, rectangle, circle?

What is the best size of parachute?

Does length of strings make a difference?

Does number of strings matter?

Does the size of the 'person' make a difference?

Some parachutes have a hole at the centre. Does this make a difference?

With all of these questions, the students should be encouraged to predict possible outcomes for all these variables and then to design, make and test their parachutes.

Are there any other things we must consider?

Would your parachute work on the Moon?

The Mars lander craft used a very large parachute when coming down onto the surface of Mars. It was about 100 times bigger in area than what would be used on Earth for the same job. What does this tell us about Mars?

See Brian Cox video of Galileo investigation with and without air. https://www.youtube.com/watch?v=QyeF-_QPSbk

A Soft Landing

What are the implications of this for Space Exploration?

Can we look at how ESA can get astronauts safely back to Earth?

ESA Activity http://esamultimedia.esa.int/docs/edu/Eggnaut_EN.pdf

Other Parachute uses.

Bloodhound: how do you stop the fastest car in the world?

https://www.topgear.com/car-news/motorsport/bloodhound-how-do-you-stop-1000mph-car

The Bloodhound Challenge http://www.bloodhoundssc.com/education using parachute to slow down car

REFLECTION

- What worked well?
- What would I change in these activities?
- Did the video trigger of Felix jumping switch them on?
- Have the students got an understanding of gravitational force?
- Did the students engage with the topic?
- What questions did the students ask?
- Does this lead on to further investigations? Can we carry any of these out? How did the groups work with planning and designing?
- Did I take into account the individual needs of my students with SEN?
- Did I ensure that the materials used were appropriate?
- What differentiation strategies worked well?
- Did I ensure that the lesson content was clear?
- Did I ensure that the materials used were appropriate?
- Was I aware of the pace at which students worked and the effort required?
- Are there cross curriculum opportunities here?
- Are the students moving on with their skills?
- **Did the students enjoy the activity?**

Considerations for inclusion

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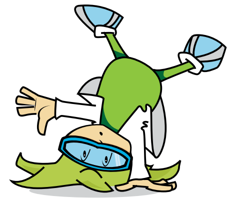
INVESTIGATION

Gravity



Class level

All

Skills

Predicting, observing, experimenting Exploring, planning, making, evaluating

Content

SCIENCE: Forces

MATHS: Number: operations
Measures: Weight – estimate and measure

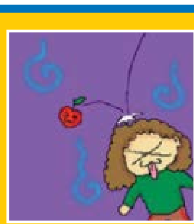
Cross - curricular links

Geography: Natural Environments: Planet Earth in Space

History: Aristotle was a very early Greek scientist *(384-322 B.C.)*, who said that heavy objects fall faster than light ones. His ideas on this and many other areas in science *(e.g. he said the Earth was at the centre of the universe)* were believed by most people for nearly two thousand years. Then Galileo and Newton came along and proved him wrong.

Equipment

1. Dropping things of different mass: One piece of paper, a stone
2. Dropping two things of same mass but different shape:
   Two pieces of paper *(the same mass and size)*
3. Dropping things in different parts of the world: Orange, cocktail sticks, plasticine:
4. Design and Make a Parachute: Tissue paper, sellotape, thread, plasticine or small Lego figure



Source: www.freewebs.com/littlemilysiencenlightenment/scientistsofthe1500s.htm

Preparation

Collection of materials

Background information

Source: http://upload.wikimedia.org/wikipedia/commons/2/22/Christa_McAuliffe_Experiences_Weightlessness_During_KC-135_Flight_-_GPN-2002-000149.jpg

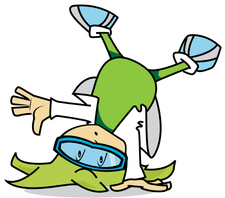
Gravity is a very useful force – it holds everything together. It keeps us on the Earth, and keeps the Earth and the other planets revolving around the Sun. Without it everything would float around. That is why it has been described as ‘The Universal Glue’.

Every object in the world has this pulling force of gravity – the bigger the object the greater the force. Earth is so big and heavy that its force of gravity is very great. The nearer things are to each other the greater the force of gravity between them.

Because the Moon is much smaller than the Earth – it is about the same width as Australia - it is not nearly as heavy as the Earth, and so gravity is much weaker there. In fact, it is only about one-sixth of gravity on Earth.

Until Galileo’s time *(around 1600 A.D.)* people thought that heavier things fell faster than light things. Galileo was an Italian scientist who **experimented** *(up to then they mainly just thought!)* and found that things with different weight fell at approximately the same speed.

INVESTIGATION
Gravity



WHAT IS 'WEIGHTLESSNESS?'

Why do we see pictures of astronauts bouncing around 'weightless' inside their spacecraft? Is this because there is no gravity in space?

No! THERE IS GRAVITY IN SPACE (*or otherwise the spacecraft would just float off into the Universe!*).

The astronauts appear to 'float' because of 'Weightlessness' inside the spaceship. The spacecraft and the astronauts **are both moving together under the influence of gravity.**

This is called **'freefall'** or **'weightlessness'.** (*The nearest feeling we get to this is being in a lift which goes down very quickly, or a rollercoaster going down quickly, or being in an aeroplane which hits an air pocket and goes down very suddenly*).

Trigger questions:

All classes:

When you let go of something, in what direction does it go?

What makes it go in this direction? (*Gravity*)

(*Pointing to Australia or New Zealand on a globe*) "What will happen to a stone when you drop it in Australia or New Zealand?" "Does it fall off into space?"

If you drop a heavy thing and a light thing at the same time, which do you think will hit the ground first?

LET'S INVESTIGATE!

Older children (*on topic of 'weightlessness'*).

Have you ever been in a lift which suddenly went down very quickly? What did it feel like? Or have you ever been in a plane which went down very suddenly and quickly when it got into an 'air pocket' of low pressure?

Or been on a roller-coaster or Big Wheel that suddenly went down? Can you remember what it felt like?

Activities:

All Ages:

Source: www.srcf.ucam.org

1. Dropping Things of Different Mass

Take a piece of paper in one hand and a stone in the other.

Which is heavier? Which do you think will fall faster? Why?

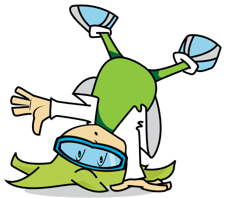
Roll the piece of paper up into a tight ball. Drop the stone and paper from the same height at approximately the same time. On account of the air resistance surrounding the Earth the lighter object may fall very slightly slower. If this activity was done where there is no air, (*e.g.in Space or on the Moon or in a vacuum*) then they would reach the ground at exactly the same time.

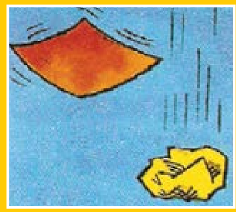
Which landed on the ground first?

Read about Galileo's famous experiment from the Leaning Tower of Pisa. N.B. It may be a legend that it was Galileo who actually performed this experiment himself.

N.B. This activity could also be done with any two similar containers, e.g. butter cartons, with different amounts of, say, sand in each; or two identical bottles - one empty and one full.

INVESTIGATION
Gravity

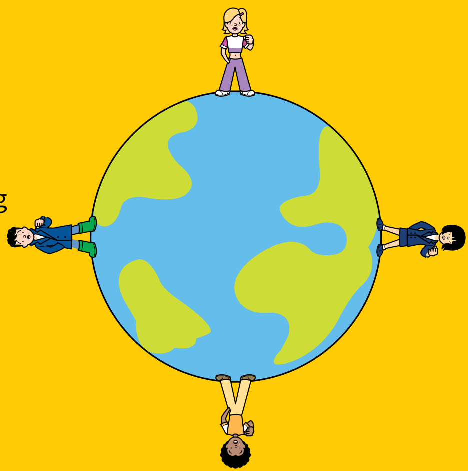




2. Take two pieces of paper and roll one up into a ball like last time and leave the other one flat. Do you think they will fall at the same speed?

Drop them from the same height at the same time. What happened this time? (*The paper in the ball probably landed first*)

Why? (*Because there is more air under the flat one, pressing up on it and slowing it down (Air Resistance). This is how a parachute works*).



3. Dropping things on different parts of the Earth.

(a) Paper, pencil. (b) Orange, cocktail sticks, plasticine.

Question? What way will gravity act in different parts of the Earth?

(a) Ask the children to draw a large circle on a piece of paper, to represent the Earth. Now ask the children to draw lots of people (*not to scale*) standing on different parts of the Earth.

(*Children find it easy to draw people 'on top of' the Earth, but find it more difficult to draw them on the 'sides' and the 'bottom' of the Earth.*)

(b) If supplies permit, give the children an orange and cocktail sticks and some plasticine.

Can they place the 'people' (*one piece of plasticine for the head, and one stick for the legs*) onto the orange to represent how these people feel gravity in different parts of the world? (*They should all have their 'legs' pointing into the centre of the orange*).

Source: www.gnurf.net/v3/clip-art/clip-artparachute- sky-jumper.html

Older children:

Reducing the effect of gravity – design and make a parachute.
Can you make a parachute?
Gravity pulls a parachute down, but as it falls air gets trapped under the canopy. The trapped air pushes up against the canopy, making the parachute fall slowly.
Can you Design and Make a Parachute? (*Remember to Explore, Plan, then Make, then Evaluate*)
Using a tissue and 4 threads, some sellotape, and plasticine or a small Lego man, can you design and make a parachute, and hang the plasticine/Lego man from it?
What happens if you add more plasticine? Does the parachute fall faster or slower?

Maths: (*Older children*)

CALCULATING WEIGHTS ON THE MOON AND OTHER PLANETS.

N.B. Weight and Mass are different. Mass is the amount of 'stuff' in something and is the same everywhere. It is measured in grams or kilograms. Weight is a force : the force of gravity on something, so it varies under different gravities, e.g. you weigh less on the Moon (*but your mass is the same*). Weight, being a force, is measured in Newtons. You will learn more about this at second-level. Mass is a measure of how hard it is to push an object on a surface.. Weight is a measure of how hard it is to lift an object. It is easier to lift an object on the Moon because the gravitational force is smaller. Hence the weight of the object is less. However it takes the same effort to push the object on a surface on the Moon as it does to push it on the same surface on Earth. The mass is the same.

For a bit more on this see the following website: http://www.askaboutireland.ie/learning-zone/primary-students/5th-+-6th-class/science/gravity/some-ideas-about-gravity/index.xml

We will just use numbers, without units, for the following exercises.

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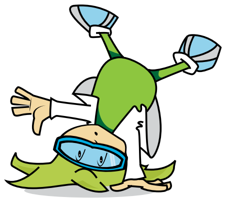
INVESTIGATION
Gravity



1. WEIGHTS OF DIFFERENT THINGS ON THE MOON

Some sample weights are given below column (*in case enough balances are not available*):

Object	Mass on Earth in kilograms	Weight on Earth in Newtons	Weight on Moon in Newtons
Sugar	1.0	10	10/6 = 1.66
Apple	0.12	1.2	
Stone	0.48	4.8	
Book	0.36	3.6	
Pencil	0.024	0.24	

(Missing figures to be filled in by the children)

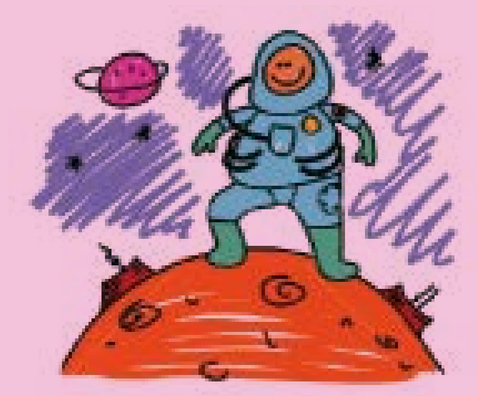
2. YOUR WEIGHT ON THE OTHER PLANETS

Let us give Gravity on Earth the number 1; then Gravity on the other planets and the Moon is greater or less than 1 depending on their mass and size compared with those of the Earth; e.g. the Moon's gravity is one-sixth (0.16) that of Earth.

Let us say your weight on Earth is 40 Newtons.

How much would you weigh on the Moon? - 6.4 N. *(Missing figures to be filled in by the children)*

Body	Gravity	Your Weight in Newtons
Earth	1	40
Moon	0.16	40 x 0.16 = 6.4 N
Mercury	0.37	
Venus	0.86	
Mars	0.38	
Jupiter	2.6	
Saturn	1.1	
Uranus	1	
Neptune	1.5	



Safety

Care needed if children stand on chairs in order to drop things from a height. Care needed with pointed cocktail sticks.

Follow-up Activities

1. The children can carry out various investigations while designing and making parachutes. e.g. "What do you think will happen to the speed of the parachute when you change (a) the weight hanging from it?

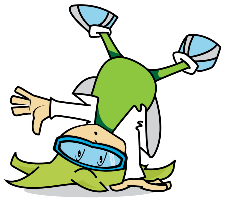
(b) the size of the material? (c) the type of material? (d) the shape of the material?

Remind them to change only one thing at a time:

"What do we keep the same?" (*e.g. type of material, shape of material, weight hanging from it*)

"What do we change?" (*e.g. the size of the material*)

INVESTIGATION
Gravity



2. As hands-on activites relating to ‘Freefall’ or ‘Weightlessness’ are not very practical to carry out in the primary classroom, a video would be more feasible (*see websites below*).

Did You Know?

Because gravity is pulling with only about one-sixth of the force on Earth, astronauts can jump about 4 metres high on the Moon! How high do you think you could jump on the Moon?

Being ‘weightless’ may sound fun, but it can also cause problems. Liquids, foods, tools and sleeping people have to be strapped down in spacecraft to keep them from drifting away.

Imagine trying to wash if the water keeps floating away!

Astronauts get a bit taller and their muscles get weaker if they are experiencing weightlessness over time. They usually recover when they return to Earth.

Scientists are experimenting with growing plants in weightless conditions in the International Space Station, in order to try to produce a biofuel faster. The results could help produce alternative energy crops on Earth.

The European Space Agency is building a super robot, called EUROBOT, with several hands and super strength, which will be able to do amazing things in space.

Useful Websites:

An interactive website testing Galileo’s famous experiment: Dropping heavy and light objects from the same height on the Leaning Tower of Pisa: www.pbs.org/wgbh/nova/galileo/expe_flash_1.html

The American space agency NASA’s website has Galileo’s experiment being performed, by an astronaut on the Moon, using a feather and a hammer: http://er.jsc.nasa.gov/seh/feather.html

The learning zone of the Library Council’s website ‘askaboutireland’ has lots of interactive science experiments on various topics, including ‘Gravity’: http://www.askaboutireland.ie/learning-zone/primary-students/5th-+-6th-class/science/gravity/

To test the speed of an astronaut going into freefall, see the European Space Agency’s:

To see what it is like living in space, have a look at: http://www.esa.int/esaKIDSen/Livinginspace.html

A soft landing
Space technology

time
60 minutes

learning outcomes
To:
- know what speed is
- know how you calculate speed
- know that spacecraft need to make a soft landing

end product
- a landing craft for an egg

materials needed
- photograph of Mars Lander (Appendix)
- 12 containers
- 12 pencils
- 12 erasers
- 12 stopwatches
- 12 eggs (raw)
- A4 paper
- drinking straws
- sandwich bags
- wooden skewers
- string
- tape
- elastic bands
- scissors
- sticky tape
- plasticine
- cotton wool
- aluminium foil
- optional: prize for the competition

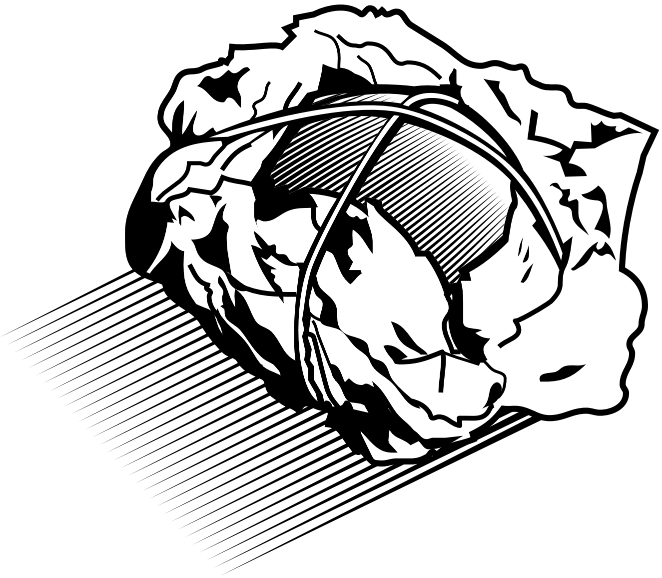
Preparation
For the activity **To brake or not?** you will need the photograph of the Mars Lander from the Appendix. Place the following items into each of 12 containers: A4 paper, straws, sandwich bags, wooden skewers, string, tape, elastic bands, scissors, sticky tape, cotton wool, aluminium foil and plasticine.

To break or not? 10 min.
Organise the children into pairs. Give each pair a pencil and an eraser. The children drop these from a height of one metre above their table. What happens? Ask the children what causes the pencil and eraser to fall. Explain that this is because of gravity. Ask the question: 'How could you make sure the pencil and the eraser have a soft landing?'
Explain that space vehicles land on other planets to carry out research. The Mars Lander is one of these vehicles. Show the photograph of the Mars Lander. Ask the children how the Mars Lander got to Mars. Explain that it was important for the Mars Lander to make a soft landing, so it was fitted with parachutes and a type of airbags. Explain that the children are going to make their own landing craft. Not a Mars Lander, but one to land an egg. What can they do to make sure their egg doesn't break?

The children make a landing craft for an egg.

Land your egg! 40 min.

Ask the children how they think they could safely land an egg falling from one metre above their table. Write their ideas on the board. Hand out the containers with the items they will need and encourage the children to examine the contents. Then discuss the conditions which the landing craft should fulfil, as described on the worksheet. The children draw their design in the box at Task 1 on the worksheet. Help the children to make their designs. They may like to make something that resembles the drawing below.



Tip. Finish the lesson with a competition. Who built the best landing craft? Who managed to land their egg without breaking it? The children drop their landing craft from an increasingly greater height. Which landing craft landed the egg safely from the greatest height? How high was that?

The children make their landing craft according to their designs. Explain that they may not start to build until their design has been approved.

The children start by testing their landing craft using a ball of plasticine before using the real egg. Is the plasticine dented after landing? Why? Discuss the results with the children. Which pair's landing craft worked the best? Look at their design. What made it special? Encourage the children to look at each other's designs and test them with the plasticine, so they can learn from each other. When they have finished, they can make any necessary improvements to their design.

What is the average speed? 10 min.

Explain that the egg fell from a height of one metre. Now the children calculate the speed of their egg during its fall. The children complete Task 2 on the worksheet. Explain that if you know the distance an object travelled and the time it took to travel this distance, you can calculate the average speed of the object.

Tip. If it proves difficult to measure the average speed at this distance, you may choose to replace the egg with the plasticine and encourage the children to drop their craft from a greater height.

A soft landing

You are going to make a landing craft for an egg.

1 Land your egg!

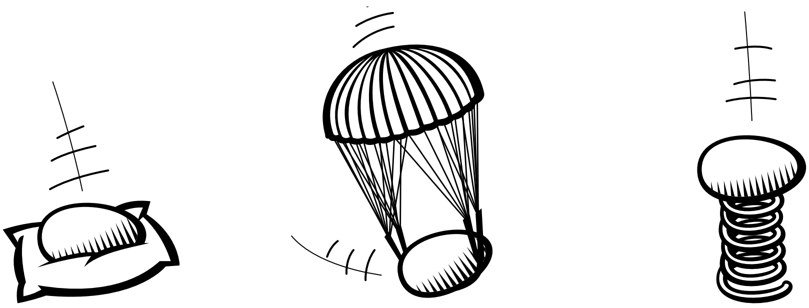
1 Design a landing craft.

Examine the items in the container. You do not need to use everything.

Take the following conditions into account:

- your landing craft must be able to stand upright unaided
- you may not fix your landing craft to the ground
- your landing craft must land without breaking your egg

You can see some examples in the following drawings.



draw your design HERE

2 Build your landing craft!

3 Test your landing craft! Carry out a test using a ball of plasticine before using your real egg.

4 Improve your design if necessary.

2 What is the average speed?

What do you need?

- egg
- stopwatch

What do you need to do?

1 Carry out this experiment in pairs. One of you holds the egg landing craft, the other holds the stopwatch.

2 Drop the landing craft from a height of one metre and start the stopwatch at the same time.

3 Stop the stopwatch as soon as the egg reaches the ground.

a What distance did the egg travel? ____________ metres

write your answer HERE

b How long did your egg take to travel this distance? ____________ seconds

c Write the information in the spaces provided.

Our egg took ____________ seconds to travel ____________ meters.

The average speed of our egg was

____________ meters : ____________ seconds = ____________ meters per second.

Mars Lander • LESSON 80

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