Physics

Robots: Working together

This lesson will investigate the movement of robots that could be used to colonise Mars.

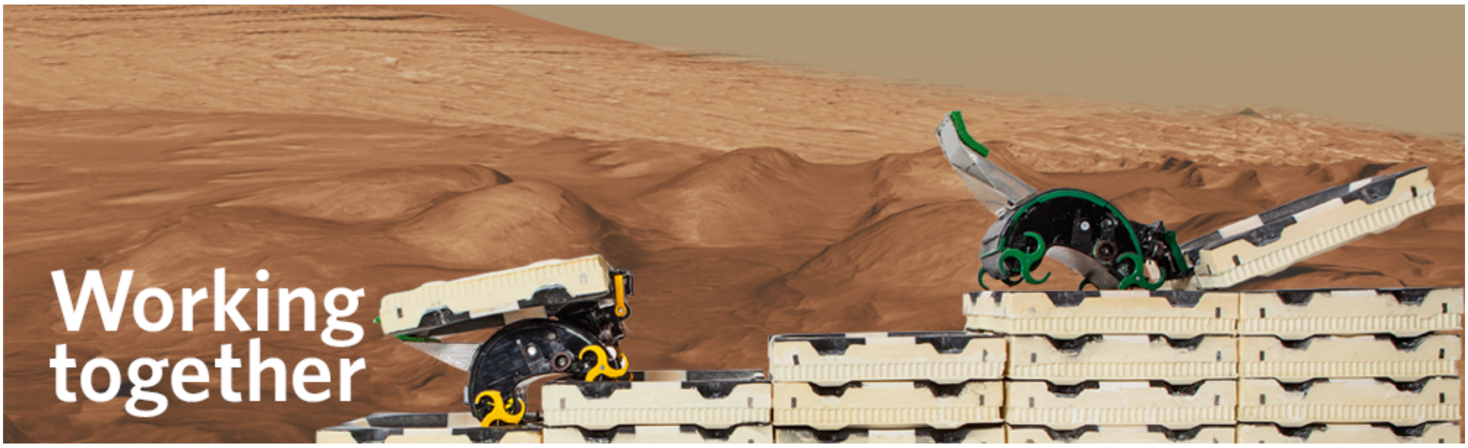
We will look at questions such as:

- What is a force?
- How do objects move?
- How do we show forces are acting on an object?

Watch the videos, draw diagrams and create an advertising brochure to share your love of robots.

This is a print version of an interactive online lesson. To sign up for the real thing or for curriculum details about the lesson go to **www.cosmosforschools.com**

Introduction: Robots (P1)



Robots could build the first homes on Mars. But instead of sending one big, strong robot to do the work, the latest idea is to use lots of small robots - each about the size of a toy truck. These pathfinder builders are a brand new invention by scientists who used termites as inspiration for their design.

Each little robot would have its own job to do, piling up bricks in order, but all the robots working together would build to a bigger plan – just as termites do to build their nests from mud.

The robots are very light, but they and the bricks they carry would be even lighter on Mars, thanks to its much lower gravity. They are very mobile, too, because they have a combination of wheels and legs (which the scientists call “whegs”) that let them climb up the bricks as they build higher and higher.

At the end of the lesson you will meet one of the scientists who builds and programs these termite-inspired robots.

Read the full *Cosmos* Magazine article [here]

Left: Termites busily working. Right: One of the termite robots that could potentially conquer Mars. Image credits: iStock & Self-organising systems research lab, Harvard University.

Question 1

Propose: The robots mentioned above were made to behave like termites. Why do you think the designers drew inspiration from this insect?

Gather: Robots (P1)

Video credit: Pheonix Film and Video / YouTube.

Question 1

Define: What is a force?

Question 2

Recall: What can a force do?

Hint: You may select more than one.

- [ ] Cause movement
- [ ] Give energy
- [ ] Transmit information
- [ ] Change the shape of an object

Question 3

Recall: The termite-like robots can climb the stairs by

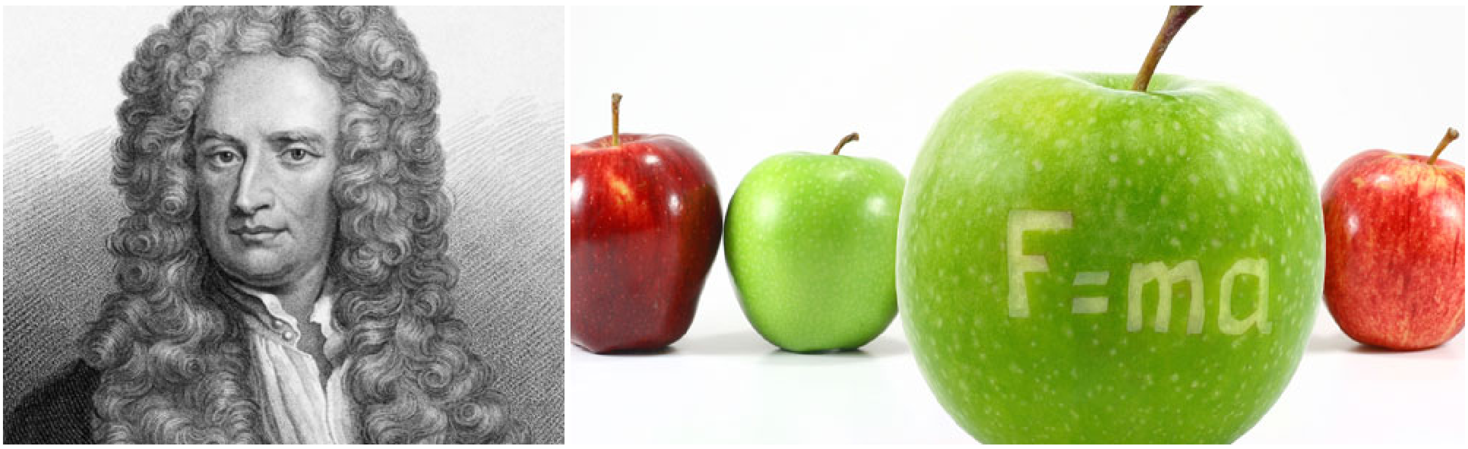
- [ ] twisting their bodies
- [ ] pushing off the ground
- [ ] pulling on the air
- [ ] extending their legs

Question 4

List: How many forces can you name?

Question 5

Describe: With the aid of the above video and an internet search if required, explain what gravity is in terms that a Year 5 student would understand.



Sir Isaac Newton made significant contributions to science, including coming up with a mathematical formula to describe the relationship between force, mass and acceleration. Image credit: iStock.

Did you know?

When someone tells you that they weigh 52 kilograms, they're not telling the truth! Weight is in fact measured in a special unit called Newtons and changes with gravity. So you would weigh less on the moon than on Earth and you would be weightless in outer space. Your mass, on the other hand, is the same no matter where you are in the cosmos. Mass is measured in grams and kilograms.

Like weight, all forces can be measured in Newtons. The size of a force can be calculated using the following equation:

Force = mass x acceleration

This formula can be written using symbols:

F = m x a, or simply, F = ma

As previously mentioned, your weight changes with gravity. You can determine your weight by multiplying your mass (in kg) by the acceleration due to gravity (which is roughly 9.81 ms^{-2} on Earth).

Sample question:

Sarah has a mass of 47 kg. What is her weight on Earth?

Solution:

Using the formula **F = ma**, we can calculate that Sarah's weight on Earth is equal to 47 x 9.81 ≈ **461 Newtons**.

Question 6

Calculate : An apple has a mass of 100 grams, what is the apple's weight on Earth?

Hint: How many grams are there in a kilogram?

Question 7

Calculate: The termite robots referred to in the *Cosmos* Magazine article weigh 7.85 Newtons on Earth. What would their weight be on Mars?

Hint: The acceleration due to gravity on Mars is equal to roughly 3.7 ms^{-2}.

Process: Robots (P1)

Left: A termite robot at work. Right: The work of thousands of individual termites can result in impressive structures like this termite mound. Image credit: Self-organising systems research lab, Harvard University & iStock.

Question 1

Calculate: The foam bricks carried by the robots are 20 cm long, 20 cm wide and 4 cm high. 1 m^3 of the same foam has a weight of 0.25 Newtons. How many foam bricks would weigh 0.25 Newtons?

- [ ] 5
- [ ] 25
- [ ] 500
- [ ] 625

Question 2

Calculate: A termite mound can be as tall as five metres. If the robots were stacking the foam bricks one of top of the other, (each brick being 4 cm high), the number of bricks needed to build a five-metre pile would be:

- [ ] 5
- [ ] 25
- [ ] 75
- [ ] 125

Question 3

Explain: The robots were designed to have "whegs". Give the reasoning behind this combination of legs and wheels and how they help the robot move.

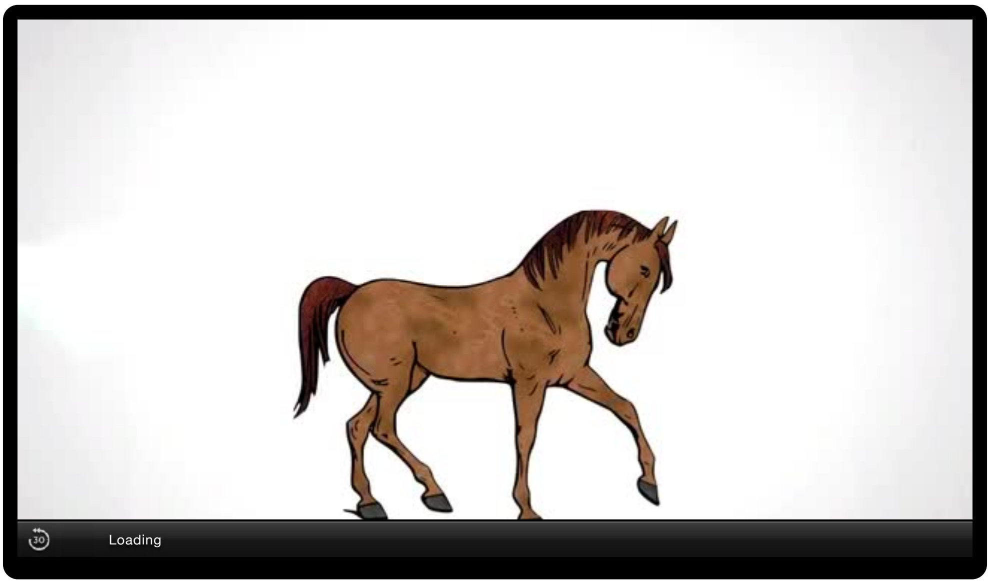
Video credit: Veritasium / YouTube.

Question 4

Think: What forces are acting on you now?

Question 5

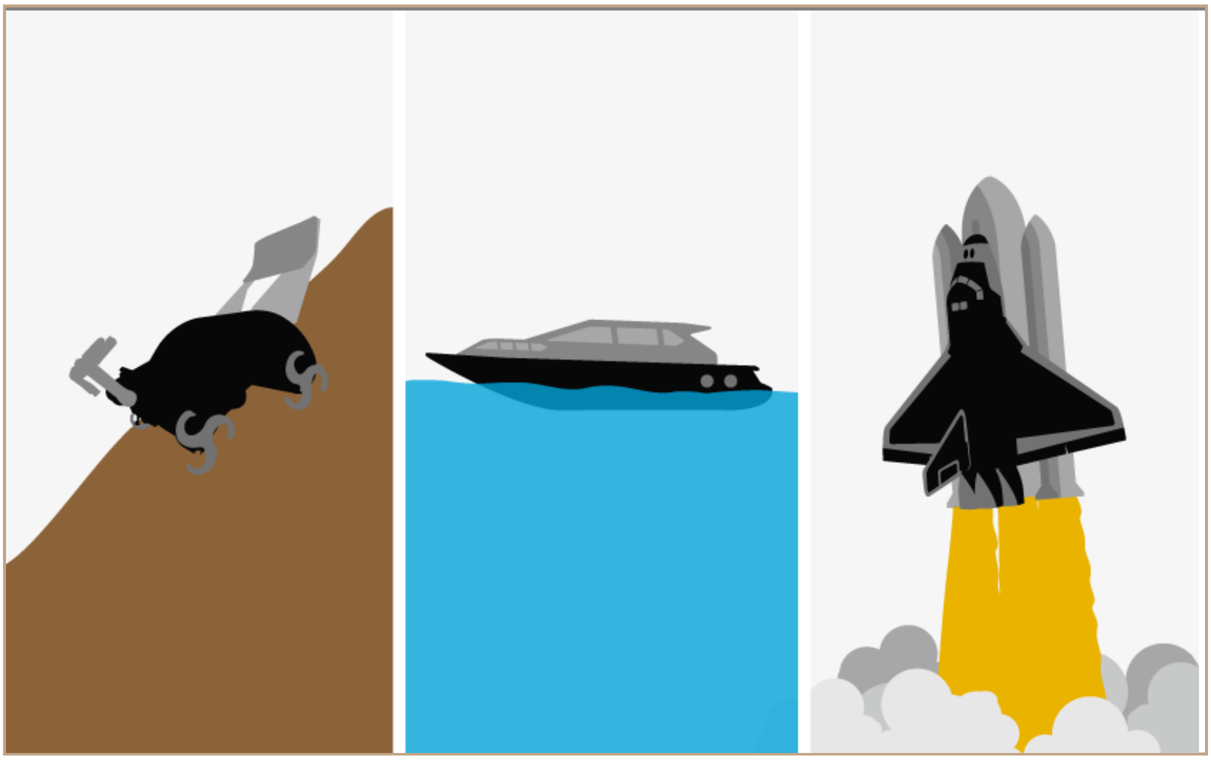
Construct: Draw arrows on the images below to show the forces acting on the central object. Take care to show the relative size of each force and label each force. The first one has been done for you.



Video credit: The Fuse School / YouTube.

Question 6

Generalise: Draw arrows and label the three diagrams to show your understanding of balanced and unbalanced forces.



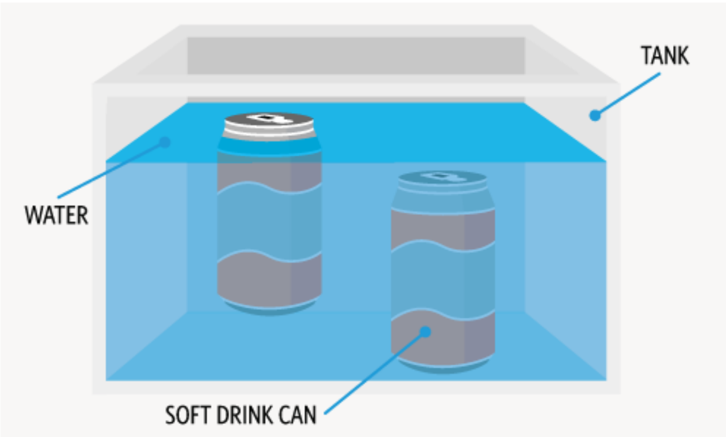
Question 7

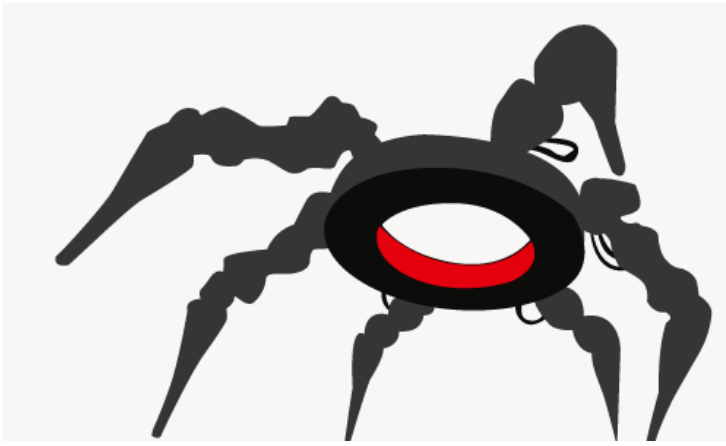
Analyse: Given the size and direction of a force the observed result can be found. Complete the table below, the first row has been filled out as an example.

Pushing force (in Newtons) *to the right*	Pulling force (in Newtons) *to the left*	Observed result
20	100	20 - 100 = - 80 N, the object will move to the left
50	50	
5	2	
64	16	

Apply: Robots (P2)

Buoyancy, sugar and robots





You now have a choice of activity to complete. You may choose from the following two options:

- Design an experiment: Floating cans
- Design a brochure: Clever robots

Design an experiment: Floating cans

Question 1

Predict: A TV presenter demonstrates floating and sinking (the video is included below). Before you watch the video predict whether each can will float or sink.

Objects	Float or sink?
Can of Coke	
Can of Diet Coke	
Can of sparkling water (Big K)	

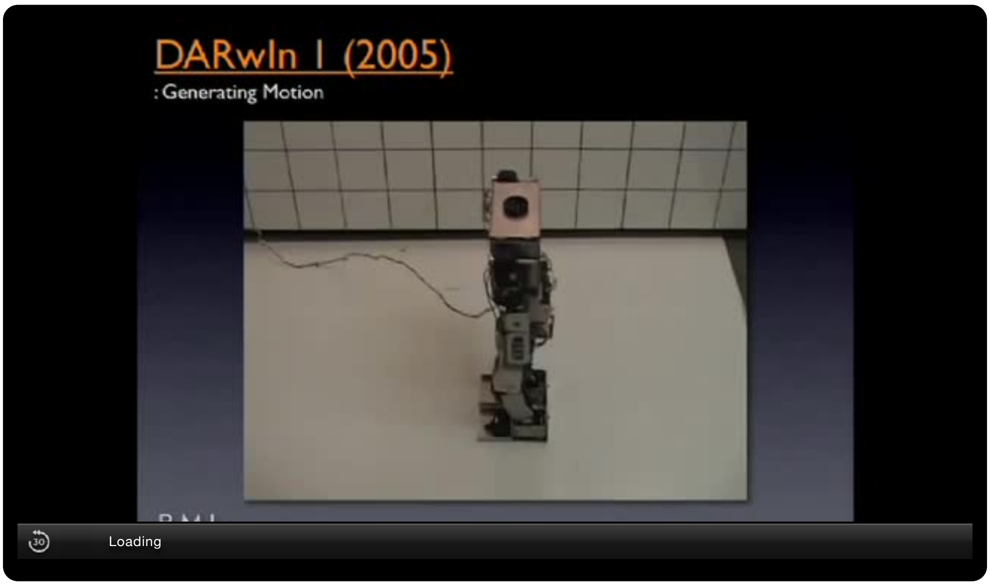
Video credit: Spangler Science TV / YouTube.

Question 2

Design: The above video shows that the density of soft drinks depends on their sugar content. Using this knowledge, devise an experiment to *measure* the amount of sugar in a drink. You will need to include:

- An aim (a statement of what you are trying to achieve in your experiment).
- A list of independent, dependent and controlled variables (what you will change, what you will measure and what you will keep the same).
- What materials you will need.
- A method for your experiment (a set of instructions like a cooking recipe for another student to be able to follow. You may include a diagram of your set up).

Design a brochure: Clever robots



Video credit: TED / YouTube.

Question 3

Create: Design a brochure for one of Dennis Hong's robots. Your brochure must include:

- A description of what the robot can do.
- A diagram of the forces used when the robot is working.
- An explanation of what inspired the designers.

Hint: You may draw your brochure using pencils and paper and upload a photograph of your brochure using the "Files and media" button.

Careers: Robots (P2)

Brought to you by Queensland University of Technology

Kirstin Petersen is a Danish electrotechnical engineer who designs, builds and programs robots. She is one of the minds behind the termite-inspired robots that you have been reading about throughout this lesson.

Growing up, Kirstin was always fascinated with astronomy and exploring other planets. But one day, at a student involvement program at NASA's Jet Propulsion Laboratory in California, something happened that would change the shape of her career.

There she saw a fantastic "six-legged robot that could climb around on solar panels and clean them with its front legs". She thought it was amazing and found out that the woman who designed it was an electrotechnical engineer. So, in a split-second decision, Kirstin knew that this was what she wanted to do.

For Kirstin, designing robots is not just a job, it's also a lot of fun. She says it's "kind of like doing a hobby, but you're paid to do it every day. It's pretty fantastic!". Not only does she design and build robots and the software that makes them run, she also does test runs and demonstrations in the field.

Kirstin says that it's creativity and a love of challenges that makes an excellent robot designer – the ability to see a problem and to think outside the box to find innovative ways to solve it. In her work, she is always asking "how can we do this better?" and she tries to find solutions that are simple but reliable.

When she's not playing around with her latest robot prototype, Kirstin enjoys hiking, travelling and drawing.

Question 1

Propose: Imagine that you are applying for an internship to travel to Denmark and work with Kirstin to build your very own custom robot. Describe what you would want your robot to look like. What would its functions be? What would its benefits be? What would you call it?

Hint: If you wish to sketch ideas for your robot design using pencils and paper, photograph your drawing and upload it using the 'Files and media' button.

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