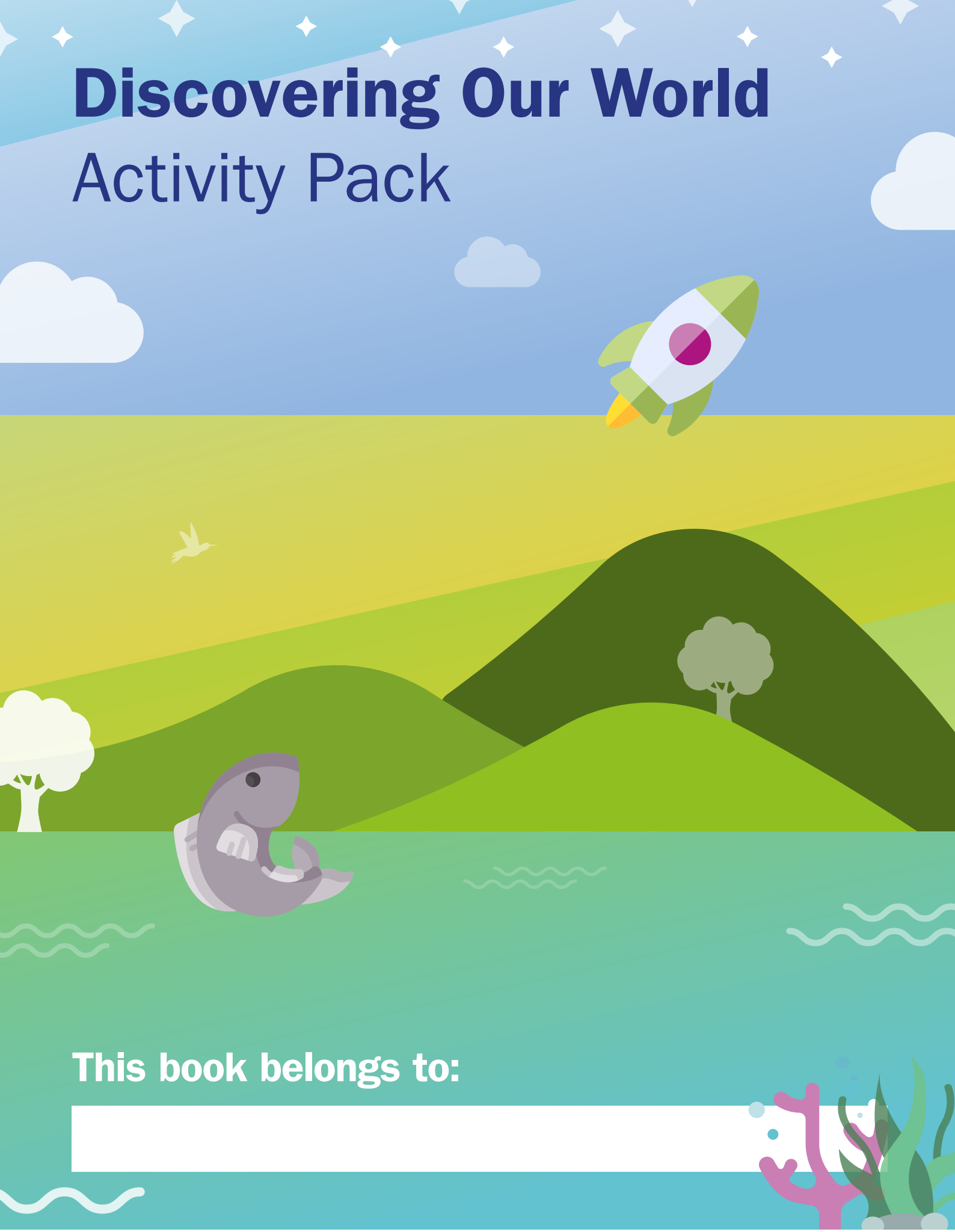
Discovering Our World
Activity Pack



This book belongs to:

Limit Less

IOP Institute of Physics

This activity pack has been created by the Institute of Physics, with content authored by Dr Sarah Bearchell.

Huge thanks to:

Dr Kristin Burmeister

Dr Krishna Mooroogen

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RAL Space

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Introduction

Information for parents and carers

We hope you and your family enjoy this new activity pack from the Institute of Physics.

Discovering Our World is in three parts: Under the Sea, On the Ground and Leaving the Ground. You'll find experiments and activities to do together and interesting articles and word puzzles to help build your child's literacy and grow their vocabulary.

This pack has been designed for children aged 8 and over – please supervise your child and help them where needed to do any activities, especially those involving scissors. These experiments have not been specifically safety tested for home use, but we believe them to be safe if the instructions are followed. Adult supervision or direction is recommended as appropriate. All experiments are carried out at your own risk.

Limit Less

We hope that this activity pack will help spark curiosity and conversations with your child about the world around them and even about their future. This activity pack is part of a campaign from the Institute of Physics – Limit Less.

Now, more than ever, we need to support our children and young people to help fulfil their potential. Studying physics lets them explore how the world works – and how to change it. However for some children this is less likely than for others. We want that to change. We want every child to have the chance to build the future they want. To find out about what we are doing please visit:

www.iop.org/LimitLess

Looking for more?

If you've enjoyed this activity pack and are looking for more activities to do together, please visit the IOP website: **www.iop.org/AtHome** for webpages about the physics of the world around us, experiments that you can do at home and other activity packs.

If you'd like to share a photo of your family taking part in any of the activities in this pack, we would love to see them! Please share on social media with **#IOPAtHome** and tag us:

twitter.com/PhysicsNews
facebook.com/instituteofphysics
instagram.com/institute_of_physics

If you have any questions or would like to find out about the Institute of Physics, please email us at **engagement@iop.org**

Rocket Hunt!

Can you find the rockets we have hidden through the book? Answers on page 41

Contents

Under the Sea

Credit: Kristin Burmeister

Meet a Physical Oceanographer:
Dr Kristin Burmeister

What do you do?

I'm a physical oceanographer (say *ocean-og-ra-fer*), which means I am a scientist who studies the physics of the ocean. I measure the temperature of the ocean and investigate changes of ocean currents – which are like rivers in the ocean but much bigger than those on land. I am based at the Scottish Association for Marine Science in Oban.

Where did you grow up?

I grew up in a small village in the middle of Germany, far away from the ocean. However, my family would spend at least one holiday each year somewhere at the sea and I loved it ever since.

Which three words describe you?

Happy, active, exploring

What job did you want to do when you were at primary school? What changed your mind to study physics?

Since I can remember, I always wanted to become a marine biologist. I still remember a sign on my door that my older cousin made me, saying This

is the office of Dr. Kristin Burmeister. Back then I didn't even know what Dr. means!

In school, I never was as good in biology as in physics, chemistry, or maths – so my dream job needed a tiny bit of adjustment. I replaced biology with my favourite subject – physics – and became a physical oceanographer instead. The old sign from my cousin became reality after all!

What kind of things do you do in your job?

Each day is a bit different from the others. I spend a couple of weeks each year, studying the ocean on a big research vessel (ship) at sea. Then I use my PC to analyse the data I collected and compare them to ocean models. I also share my work with other scientists and teach students to become the marine scientists of tomorrow.

What's the best thing about your job?

Through my work I travel to a lot of countries in Europe, North and South America and Africa. I also spend a lot of time in the middle of the Atlantic and Pacific Oceans which is very special to me. I get to explore first-hand how our earth is working.

How do you think your job will change in the future?

I think the biggest change will be to travel less. The last 1.5 years showed us that some meetings can be replaced by virtual events, but not everything can be done online. We need to find the right balance for science and the environment.

Which of the skills you learned when studying physics are most useful in your job?

Oh, this is a difficult question! I make use of everything I learnt! Maybe the most useful things were computer programming and attending field trips because they help with my work now.

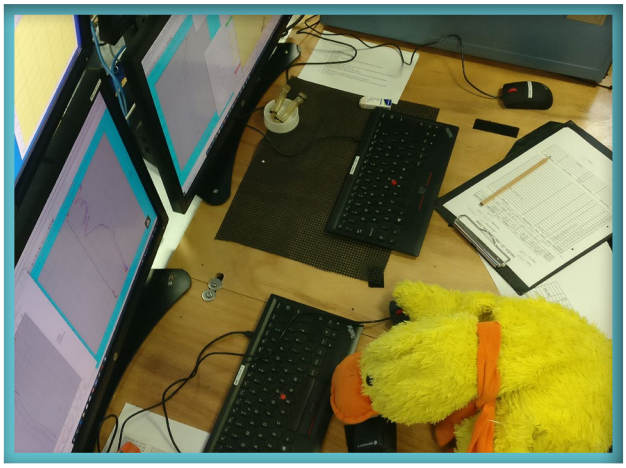
What do you like to do in your spare time? What makes you happy?

Scuba Diving! This is my most favourite, but in general I love to be active and to be outdoors. I enjoy doing yoga, cycling or hiking through the Scottish Highlands and spending time with friends and family while doing so.

Credit: Joe Marlow

If you went to space, which luxury item would you want to take with you?

The Family Duck! Each member of my family has a giant yellow duck called The Family Duck. It is as big as a pillow and I try to take it everywhere, even on research cruises. Of course, it is well trained to help us with our measurements! (see pic).



Credit: Kristin Burmeister

Make a diving Oceanographer

Physicist Kristin Burmeister, likes to scuba dive in her spare time. She has inspired this making project.

Before you start

Make sure you keep the plastic bag away from pets or young children.

What you'll need:

- Plastic supermarket bag or sandwich bag
- Paper clip x 3
- Cotton thread (20cm)
- Scissors
- 2l straight-sided plastic pop bottle
- Cold water
- Teaspoon
- Mug
- Cereal bowl
- Helper

Optional

- Marker pen

What to do:

1. Cut a 20x20cm square of plastic bag.

2. Optional Step: Use a marker pen to draw a 2cm tall scuba divers face, so the chin is about 2cm above the centre of the plastic. This diver has an eye mask and a gas regulator with a hose to the air tank.

3. Lay the plastic across a mug with the ink side downwards. Put the middle of the plastic in the middle of the mug. Push the bag down with your finger, to make a well. Add two teaspoons of cold water to the centre.

4. Carefully gather all the edges of the plastic to collect the water in the middle. Ask your helper to tie the thread TIGHTLY around the gathered part, so that MOST BUT NOT ALL of the air is kept out. Wrap it round about 5 times and tie the cotton very tightly. Cut off the extra cotton. This will make a bag of water with a little bit of air in it.

5. Bend out one end of a paperclip and carefully tuck it behind the thread. Add a second paper clip in the same way.

6. Use scissors to cut away the extra plastic, leaving about 2cm next to the thread.

7. Now test for buoyancy (say boy-an-see) – it just means floatiness! Place the diver in a bowl of water and jiggle it to remove any air bubbles

from the surface. Most of the diver should be just under the surface.

If it floats on top of the water, it is too **buoyant** (say *boy-ant*) - add an extra paperclip. If it sinks completely, it is not buoyant enough - try carefully removing one paperclip or using a smaller one.

8. Almost fill the pop bottle to the top with cold water. Carefully add the diver, then use a pencil to jiggle it and release any bubbles from the surface.

9. Now fill the bottle until it just starts to overflow and put the lid on *really tightly*. This is to stop you getting really wet in the next step!

To make it work

Press *really hard* on both sides of the bottle and watch what happens. Then relax your hands – what happens?

The diver should sink to the bottom when you squeeze and then float back up when you release it.

If it doesn't work:

- check for air bubbles trapped in the cut plastic ends
- check the bottle is filled right to the top
- check the lid is on very tightly
- If you accidentally drop the bottle, extra water is forced into the diver and it will stay sunk. You'll need to take it out and remake it.

How does it work?

You have made a Cartesian (say *car-tee-see-an*) Diver! The diver is made from about 1-2g of plastic and a little bit of thread. You filled it with water and a little air bubble. It floats in water because the gases in the air bubble are less closely packed together than the particles in the water. This makes it float. We say it is less dense than the water.

When you added the paper clips, they added lots of closely packed metal particles. These made the whole diver **more dense** than the water, so it sank just under the surface.

Pushing on the sides of the bottle increases the pressure inside the bottle. It is hard to squash the water, plastic or paperclips, but you can squash the trapped air bubble.

When you squash an air bubble, the gas particles are pushed closer together, making it **more dense.** This makes the whole diver **more dense** and it sinks!

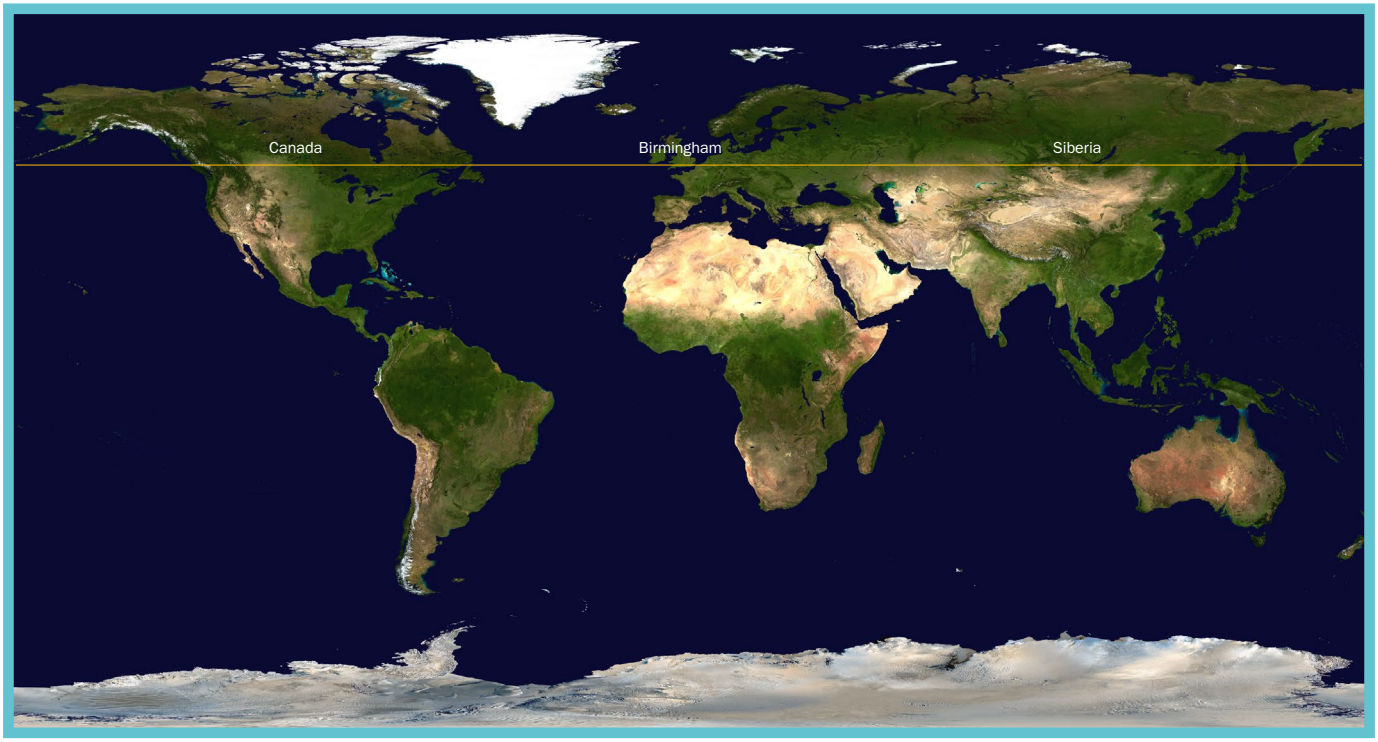
When you relax your hands, the air bubble returns to normal, and it floats back up to the top. We hope you enjoy your Cartesian Kristin!

Explore more!

Replace the diver with a ketchup sachet. It also contains a bubble which you can squeeze!

Does it work the same with warm water in the bottle?

Not too hot and not too cold…
…the role of ocean currents in UK climate



This is a "true colour" image of Earth, it is based on satellite data and was created by NASA in 2002. The horizontal line passes through Birmingham in the UK, but also through Canada and Southern Siberia – two places we definitely think of as cold!

Although it doesn't feel like it sometimes, the UK is actually rather warm considering how far north it is. How does that work? It is all to do with something called the ocean currents.

Currents are like rivers of sea water, flowing from A to B. There are currents all over the world; some are some are fast, some are slow, some are small and some are big. If you've ever watched *Finding Nemo,* you'll have heard about one already - the East Australian Current (EAC). There is even a giant current called the **global conveyor** (say *con-vey-or)*, which is lots of currents added together, and transports water around the world! You may be surprised to hear that the way it works it has a lot to do with density, just like the Diving Oceanographer Activity (page 8). The part of the global conveyor that helps keep the UK warm starts in tropical waters in a place called the Gulf of Mexico.

In the Gulf of Mexico the sea water is lovely and warm, especially near the surface. If you've been swimming, you may have noticed that the water near the surface is warmer than the water deeper down. This is because the warm water is **less dense** and it floats on the cold water underneath. The wind creates a current called the Gulf Stream by pushing these top layers of water from Florida up the coast of North America. When the Gulf Stream reaches Canada, part of it branches off and travels across the Atlantic Ocean towards the UK and Ireland. This branch is imaginatively called the North Atlantic Current, or NAC. As it flows past Ireland and Scotland, it brings all that warm water from Florida with it, making the temperature higher here than some of the other places on our horizontal line.

As the NAC flows north the temperature drops and by the time it reaches the Arctic Circle it is literally freezing! Now instead of the wind, it is the saltiness of the water that pushes the current along. Where sea ice forms, the salt is left behind in the water. The saltier the water, the more dense it becomes and it starts to sink. Surface water is pulled in to replace the sinking water, and the

same thing happens again. This constant pulling and sinking creates a current along the bottom of the ocean floor that makes up the next stage of the global conveyer.

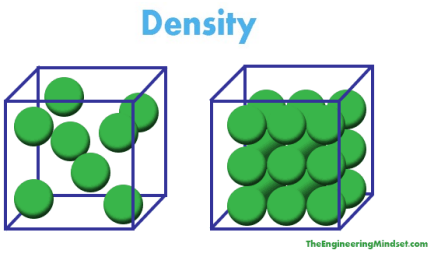
The effects of warm water floating and cold salty water sinking are called **thermohaline circulation** (say *ther-mo-hay-line, sir-cue-lay-shun*). The word *thermo* relates to temperature and *haline* relates to salt.

These major currents don't just affect the temperature of the UK, as they travel around the world they have a major impact on the climate of the whole world.

Density is a measure of how tightly packed something is. The more close together the stuff, the more dense it is…and the more dense it is, the more likely it is to sink.

In our Diving Oceanographer activity, you squeezed the bottle to push the air bubble molecules closer together. That increased the density of the diver and made it sink. The ocean can become more dense in two ways:

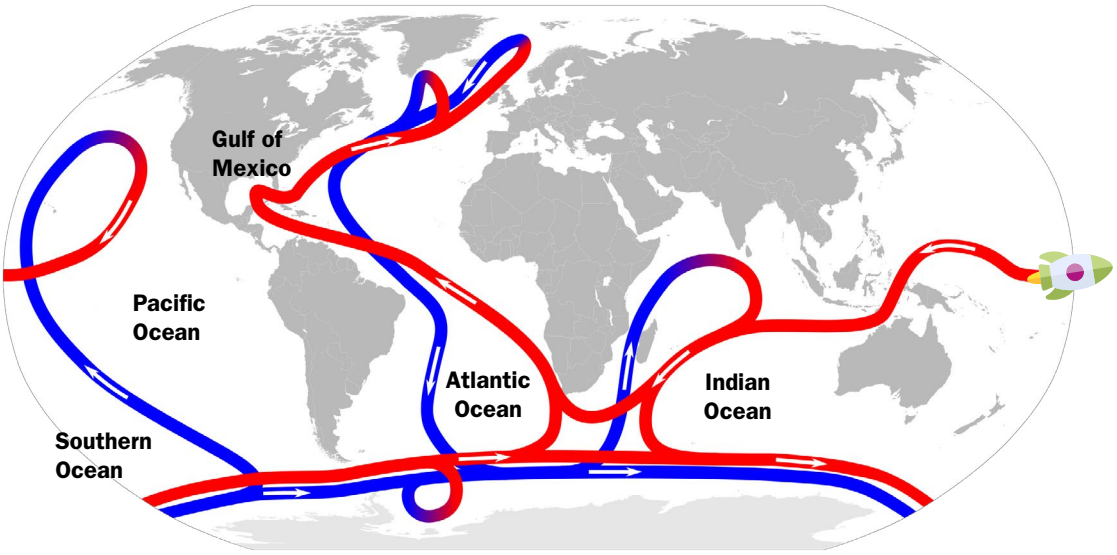
A reminder about density…



Less dense More dense

1. It gets colder. The lower the temperature of the water, the less the water molecules wobble and move, and the closer they are together (on average) so the same number of water molecules take up less space.

2. It gets saltier. This happens when some of the ocean changes state to become ice/water vapour. Then the water left behind it becomes more salty. The salt molecules go into spaces between the water molecules, so you have more stuff packed into the same volume of water.



The major currents of the ocean conveyor. The red lines show where the warm salty water travels in the upper layers of the ocean and the blue lines show the deeper, colder currents.

Wiggly Water

Did you know that water is always moving? Let's investigate!

You will need

- Glass or jam jar x 2
- Food colouring (one or two colours)
- Hot and cold tap water
- Ten minute timer (watch or phone or clock)

What to do

1. 3/4 fill each glass, one with hot tap water and the other one with cold tap water. Leave them to stand for at least ten minutes.

2. Get your eyes level with the cold water glass and very carefully add one drop of food colouring into the middle of it. It will be easier to watch if you have a helper to add the food colouring.

3. Watch what happens – can you see little doughnuts of food colouring?!

4. Repeat this until you have added a total of ten drops of food colouring.

5. Now repeat the same with the glass of hot water. Slowly add ten drops of food colouring and watch each one as it travels through the water.

6. Start your ten minute timer.

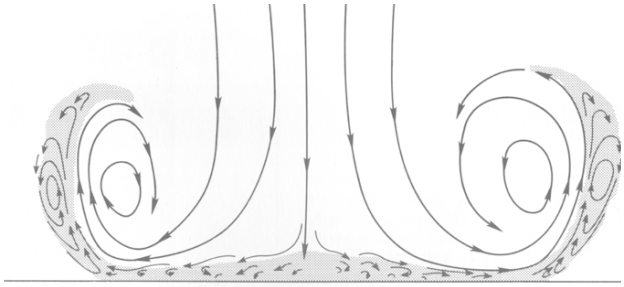
How does it work?

Did you see some little doughnuts of food colouring as the dye moved through the water? It's a pretty cool effect!

When you drip a drop of food colouring, it is no longer held by the bottle, but it starts to fall faster and faster because the force of gravity is pulling it towards the Earth.

Then, the fast-moving drop of food colouring crashes into the water! A force called **friction,** (say *frick-shun*) which resists one thing sliding over another, slows down the outside of the food colouring drop, meaning that it's now going slower than the inside of the drop. As it slows down it spreads outwards, exposing the layer underneath.

Friction pulls back this layer too, and the next and the next…curling the food colouring drop around on itself to form a rolling doughnut shape known as a vortex ring.



What next?

Look at your glasses of water as soon as you have finished adding drops to the hot water.

The food colouring settles on the bottom of the glass because it is **more dense** than the water. But can you see a difference between the jars? Some of the food colouring in the hot water (right, red) is floating around! If you leave the glasses for 10 minutes, you'll notice that the food colouring in the hot water becomes more evenly spread out than the colouring in the cold jar.

The temperature of something is a measure of how fast the molecules that make it up jiggle and move around. The hotter the water, the more the molecules move and the more opportunity they have to mix together, which is why the colouring in the hot water mixes faster.

The name for this type of mixing is **diffusion** (say *di-few-shun*). when something spreads from an area of **high concentration** (say *con-sen-tray-shun*), for example, where there is lots food colouring at the bottom - to an area of **low concentration**, where there is less of it, at the top.

Explore more!

What happens if you add two different food colourings to each jar and leave them?

What happens if you stir the water just before adding the food colouring?

Wordsearch

All these words have been used in the Under the Sea section.
Can you find them and remember what they mean?

Answers on page 40

Pressure **Oceanographer** **Buoyancy** **Dense**

Temperature **Physics** **Current** **Research**

Float **Sink** **Diffusion** **Circulation**

T	W	I	W	B	D	I	F	F	U	S	I	O	N	S	B
E	H	F	T	U	N	I	P	E	S	I	O	N	O	A	O
M	A	L	C	O	R	S	P	N	R	C	I	R	E	L	A
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On the Ground

Credit: Krishna Mooroogen

Meet an Artificial Intelligence Developer:

Dr Krishna Mooroogen

What do you do?

I am a researcher and developer in Artificial Intelligence. That means I work out how to make a computer think and act like a human. I'm currently developing a system to automatically manage traffic, working at Vivacity Labs in Islington, London.

Where did you grow up?

A small town near Brighton

Which three words describe you?

Talkative, silly, determined

How did you get where you are now?

I am Dyslexic, so I have difficulty reading and working out what things mean. I am also Dyspraxic, which makes it hard for me to coordinate things. These two conditions meant I struggled at school and failed a lot of exams during university - but I was determined to succeed!

After my degree I worked in different research labs before doing an Astrophysics PhD (a doctorate, the highest academic qualification in the UK).

This gave me the skills to work as a consultant for a national laboratory, then later I began working at tech start-ups (brand new companies).

What job did you want to do when you were at primary school? What changed your mind to study physics?

As a kid, my favourite characters on TV were always the inventors and engineers…all I wanted to do was make things! In my final year of secondary school, my science teacher shared ideas about space travel, the origins of the universe and quantum physics. It captured my imagination, and I was inspired to study physics at university.

Is your work the same every day? What kind of things do you do?

Nope. We work on many challenges! I help build models (a bit like video games) to mimic real roads and traffic. From these we create an intelligent decision maker to control all the traffic lights. I spend most of my time programming, but I also have to solve lots of logic puzzles. To do this, I look at how things work in the real world and research new ways of solving the problem.

Tell me three skills which your job needs

Tenacity (determination), some mathematics and statistics, critical thinking.

What's the best thing about your job?

Working with exciting new technologies with an excellent team of scientists.

How do you think your job will change in the future?

I think as technology gets better, we will be able to perform tasks faster and be able to analyse bigger pieces of data. This will advance the field further, so we can automate more day-to-day tasks.

Which of the skills you learned when studying physics are most useful in your job?

Problem solving is probably the biggest skill. I learned how to use information from one problem to solve another and also to break problems into smaller parts.

What do you like to do in your spare time? What makes you happy?

I have many hobbies! Video games, films, photography, reading, rock climbing, martial arts, hiking, making music….

Do you have any pets?

Two cats, Max and Gizmo

If you went to space, which luxury item would you want to take with you?

My PlayStation! Haha!

Credit: Krishna Mooroogen

Scavenger Hunt!

STOP! LISTEN!

What can you hear? Listen *really carefully…* If you are indoors, you might hear the kettle boiling in the kitchen, people talking or a neighbour listening to music.

Those sounds are made because something is **vibrating** (say *vy-bray-ting*). That means it is moving backwards and forwards, making tiny shaking movements.

Find a saucepan and a wooden spoon. Turn the saucepan upside down so that it becomes a drum. When you hit the saucepan with the spoon, the saucepan vibrates a little bit, and so does the spoon (see also "Seeing Sound"). This makes the air which touches them vibrate too. The vibration gets passed from one air molecule to the next until it reaches your ears.

The vibrating air makes your ear drum vibrate, which passes to some tiny bones then and on to the fluid in your **cochlea** (say *coch-lee-ah*). The movements of the fluid are detected by tiny hairs which send messages to your brain through the **auditory** (say *awe-di-tory*) **nerve**. This is what you hear as sound. If any part of this pathway doesn't work, you can have a hearing impairment, which means that you don't hear as well.

Some of the sounds in our environment are made by natural things – like humans talking, dogs barking and noisy weather. Other sounds are made by things which humans have made – like buses, mobile phones and the saucepan drum.

Next time you go on a walk, stop in a safe place and listen carefully. How many of these things can you hear? Can you work out if they are natural sounds or the result of a human-made object?

Listen for…	Heard it?	Natural thing or human-made?
Children shouting		Natural
Ball bouncing		Human-made
Dog barking		
Traffic		
Music from a radio		
Phone ringing		
Emergency siren		
Roadworks		
Wind blowing		
Rain splashing		
Leaves rustling		

Explore more!

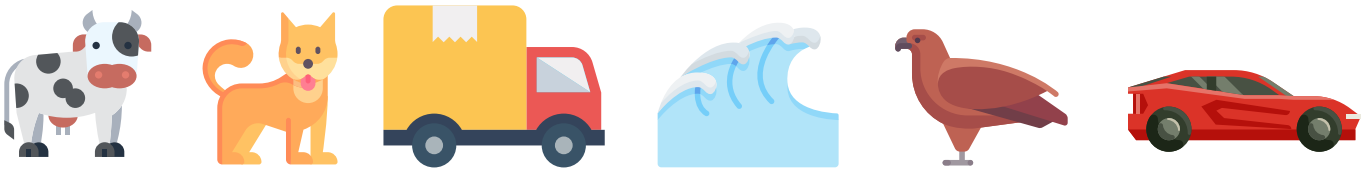
We have left some room for you to add your own sounds. Can you identify everything you hear on your walk?

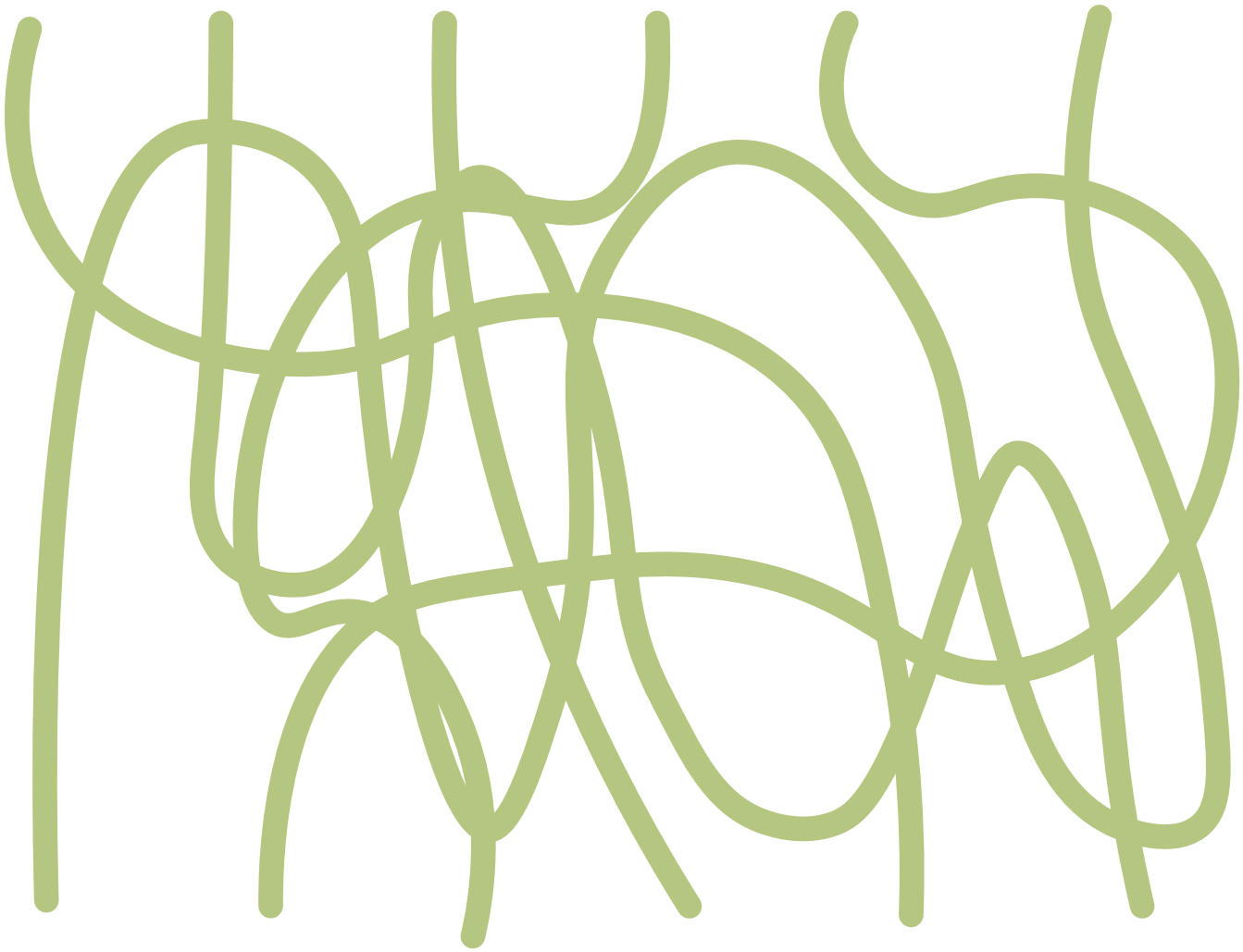
Spaghetti puzzle

What kinds of noises do these things make?
Can you make their sound?!

Some of them make a natural sound but others are **mechanical** (say *meck-an-i-cal*) because they are made by a machine.

One of the connecting lines in this spaghetti puzzle is wrong, can you work out which one?
The answer is on page 40.





mechanical **natural** **natural** **mechanical** **natural** **mechanical**

Seeing Sound!

In the Scavenger Hunt (page 18), we talked about how sound is made by vibrations. This simple sound detector will help you explore that further.

Before you start

Keep cling film away from pets and young children.

You will need

- Cereal bowl
- Cling film
- We used hundreds and thousands (cake decorations), but anything dry and grainy should work (like sand, cous-cous, salt etc.)

What to do

1. Stretch a piece of cling film over the bowl. Make sure it is really tight by stretching out any wrinkles!

2. Carefully add about a teaspoon of hundreds and thousands (or alternative) to the film. Spread them out evenly to complete your Sound Detector.

To make it work

1. Put your face close to the bowl. Close your mouth and make a really deep and loud hum! Watch what happens!

2. Try changing your hum. What happens if you change the **volume** (how loud it is) or the **pitch** (how low or high it is).

How does it work?

When you hum, you push air out of your lungs, through your vocal folds and out of your nose.

Your vocal folds are two bands of smooth muscle which **vibrate** (say *vy-brate*) when air moves past them. You can feel their tiny shaking movements if you put your hand on your throat as you hum.

Where air touches the vibrating parts of your body, it starts to vibrate too. That makes the air molecule next to it vibrate…which makes the air molecule next to that vibrate…which makes the air molecule next to that vibrate… (you probably get the picture!). (see also Scavenger Hunt)

When you hum next to the bowl, you're making the clingfilm vibrate at the same pitch as your voice. The vibrations spread out across the clingfilm and make the hundreds and thousands dance!

Explore More!

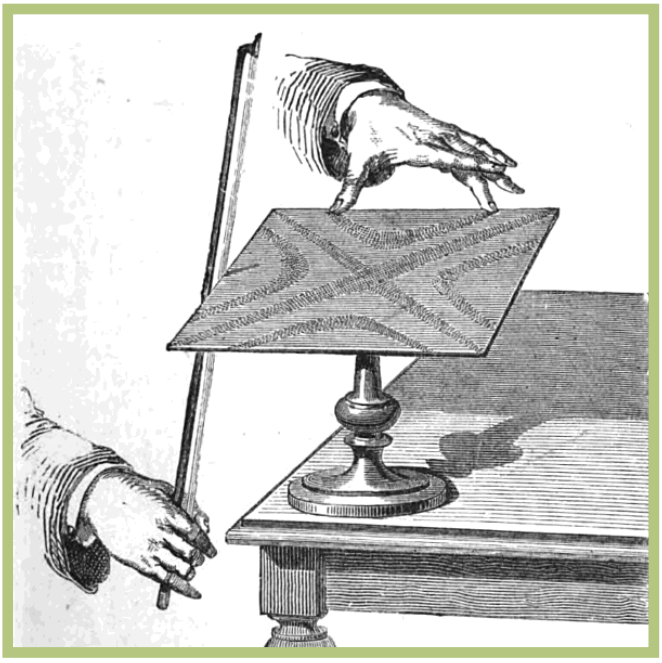
What happens if you use a different size of bowl? Try a mixing bowl!

What happens if you use a single note from a musical instrument – do you have one you can try?

What happens when you place your bowl in front of a speaker and play some music?

Making Art with Sound

Ernst Chladni was a German physicist and musician, who developed an interesting piece of equipment called a Chladni Plate. A Chladni Plate is a sheet of metal which is fixed onto a central post. Chladni placed flour on the surface and then used a violin bow to make the plate vibrate.



Amazing patterns appeared!

The plate vibrates slightly differently depending on how the note was played. The vibrating areas became cleared of flour and the still areas developed lines of flour to create distinctive patterns.

Take a look at the work of Megan Watts Hughes, a Welsh singer from around 100 years ago. She made a more complex version of the Sound Detector which she called an **eidophone** (say *eye-doh-phone*). She didn't use cake decorations, but instead used liquids and fine powders to capture the images made by sounds.

One of the images created by Megan Watts Hughes where the vibrations have created the shape of a tree.

On the Ground:

Ready for some Time Travelling with Sound?

Humans have been recording sound for almost 150 years. If you close your eyes and listen to old recordings, it's a bit like travelling back in time!

The British Library Sound Archive is an incredible free internet resource.

https://sounds.bl.uk

If you decide to access this at your local library, you might need to take some headphones with you.

The **archive** (say *are-kive*) is a collection of sounds. It includes theatre performances, music, nature sounds and recordings of different speech.

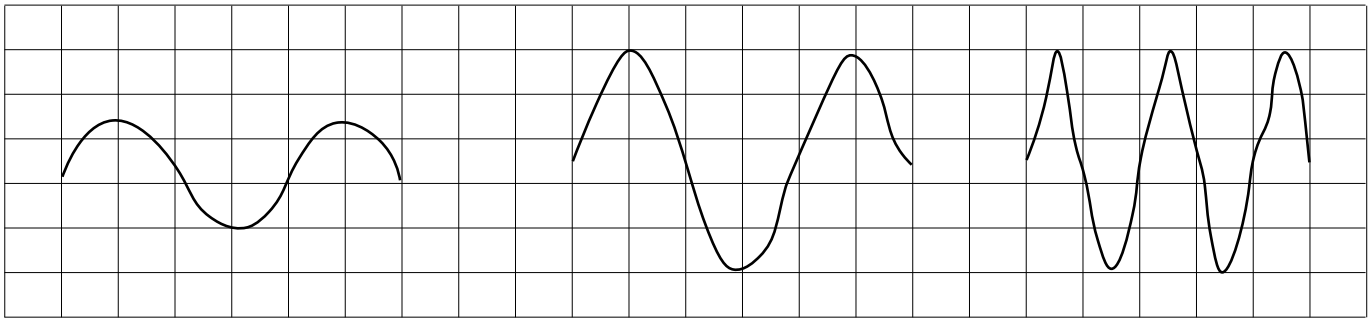
How to find things

Use the Search function on the home page. Select "Environment and Nature" from the drop-down menu and type in "Edwardian Street" for sounds from around 1910. Click the link and play the sound file.

What a busy street! You can hear horse-drawn carriages, early cars, a steam traction engine and people walking and talking. It is so different to today!

Next, search for "Steam Age Railway Station". Can you hear the whistles and chuffing of the steam engines? The train doors slam shut – there are no sliding doors with an electronic warning beep on these trains! Did you notice there are no noisy public announcements about the next train?

Each sound recording has its own sound trace. This is made by a piece of equipment called an **oscilloscope** (say *oss-sill-o-scope*). It records the changes in sound over time and turns them into a wave-shaped graph.



1 **2** **3**

This picture shows three oscilloscope traces.

Numbers 1 and 2 have the same **frequency** (say *free-kwen-see*) because the peaks are 4 squares apart on both traces. Frequency is how often something happens, and tells you how high or low the note is. A trace showing a high pitched note will have a high frequency (lots of peaks close together). A trace showing a low pitched note will have a low frequency (fewer peaks far apart).

The waves are taller in 2 than in 1. We say they have greater **amplitude** – which means they are louder.

Numbers 2 and 3 have the same amplitude – so the sound equally loud. But you'll notice the peaks are closer together on sound 3. This means it has greater frequency, so it will be a higher note.

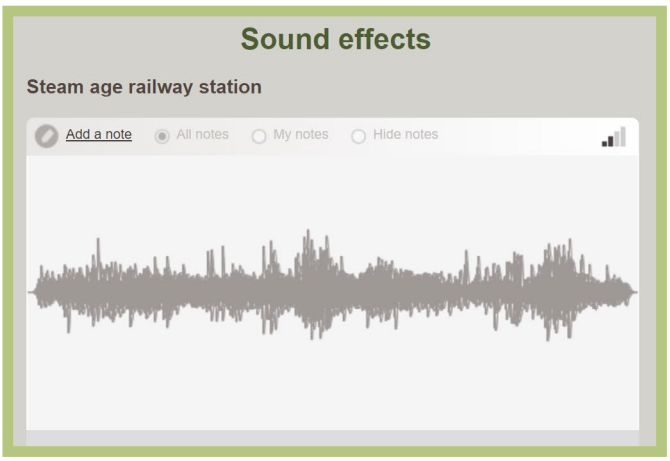
Take another listen and look at the Steam Age Railway station. Can you see that the loud sounds have tall peaks? These waves have greater amplitude. There are so many different sounds that it is hard to see the frequency of anything!

Now search for the sound of a cuckoo.

In this trace, you can see the distinct 2-note call of a cuckoo, against a background of other natural sounds.

What else can you find in the archive?

Why don't you share your favourites with us?



Credit: Copyright © The British Library Board

The art (and science!) of finding peace and quiet

What kind of noise annoys an oyster? A noisy noise annoys an oyster! Noise is any sound that you don't want to hear. It could be something too loud, or distracting. Next time you stand in a busy street, stop and listen. Can you pick out exactly what is making each sound? Is it too noisy?

You might be surprised to find out that what you hear changes depending on where you are as well as what is making the sound. This is to do with reflections. It's not only light that can be **reflected** (say *re-fleck-ted*) or bounced off a surface. Sound can be reflected too and you don't even need a mirror! All materials will reflect some sound. Hard materials like bricks, glass or tiles will reflect most of the sound and soft ones like cloth, foam or wool won't reflect much. This is why places with loads of hard surfaces, like the swimming pool, are so noisy.

Imagine shouting out to your friend on the other side of the pool. The vibrations from your shout travel away from you at about 767miles per hour or 343m/s (metres per second) through the air. When they reach the tiled wall at the end, most of the sound bounces back, and travels until it hits another hard surface, where the same thing happens. Pretty soon you have a room filled with sound. The reflected sounds join together and it can take a while for the sound of your shout to die away. This is called **reverberation** (say *ree-verb-err-ay-shun*), or reverb for short. Now imagine there are lots of people calling out! All those sound reflections can build up and it can be really hard to pick out a single voice, especially if you have a hearing impairment.

If you want to find somewhere quiet in a city, you need to stay away from noise-making things and hard surfaces. Can you think of a place with soft surfaces which will reduce sound reflection?

Try a park! In Britain, our cities have public parks which are open to everyone. At the time of writing, the city of Leeds has 62! The soft surfaces of plants and soil help to **absorb** (say *ab-sorb*) sound, that means they don't reflect it. The hard surfaces of paths and some sports pitches will still reflect sound, but the noise can escape because there are no walls or roof to trap it. This helps to make a park a relaxing, quiet place to be.

How can you make indoor spaces quieter?

The same rules apply, first think of a place where you might get a lot of sound reflections.

Do you have a tiled bathroom? Go in, shut the door and have a good shout! How does your voice sound? Can you hear any reverb? Now go somewhere with lots of soft surfaces, like your bedroom and do the same thing (Maybe explain to your grown-ups what you are doing first!). You probably found that the soft materials really helped to minimise the reverb. It's why we fill our relaxing spaces with soft items like blankets and cushions - they make your ears comfy as well as your bottom!

If you want ABSOLUTE silence, you need an **Anechoic Chamber** (say *an-echo-ic, ch-aim-ber*). In this word, "an" means without, so it is a chamber (or room) without echoes.

Everything in an anechoic chamber is designed to stop sound reflections. The room itself is built on springs to absorb vibrations from the world outside so no sound can travel into it. All the inside surfaces are covered in big chunky wedges of foam – and there is a special trampoline-like floor above the foam. You can see it in the picture on the next page.

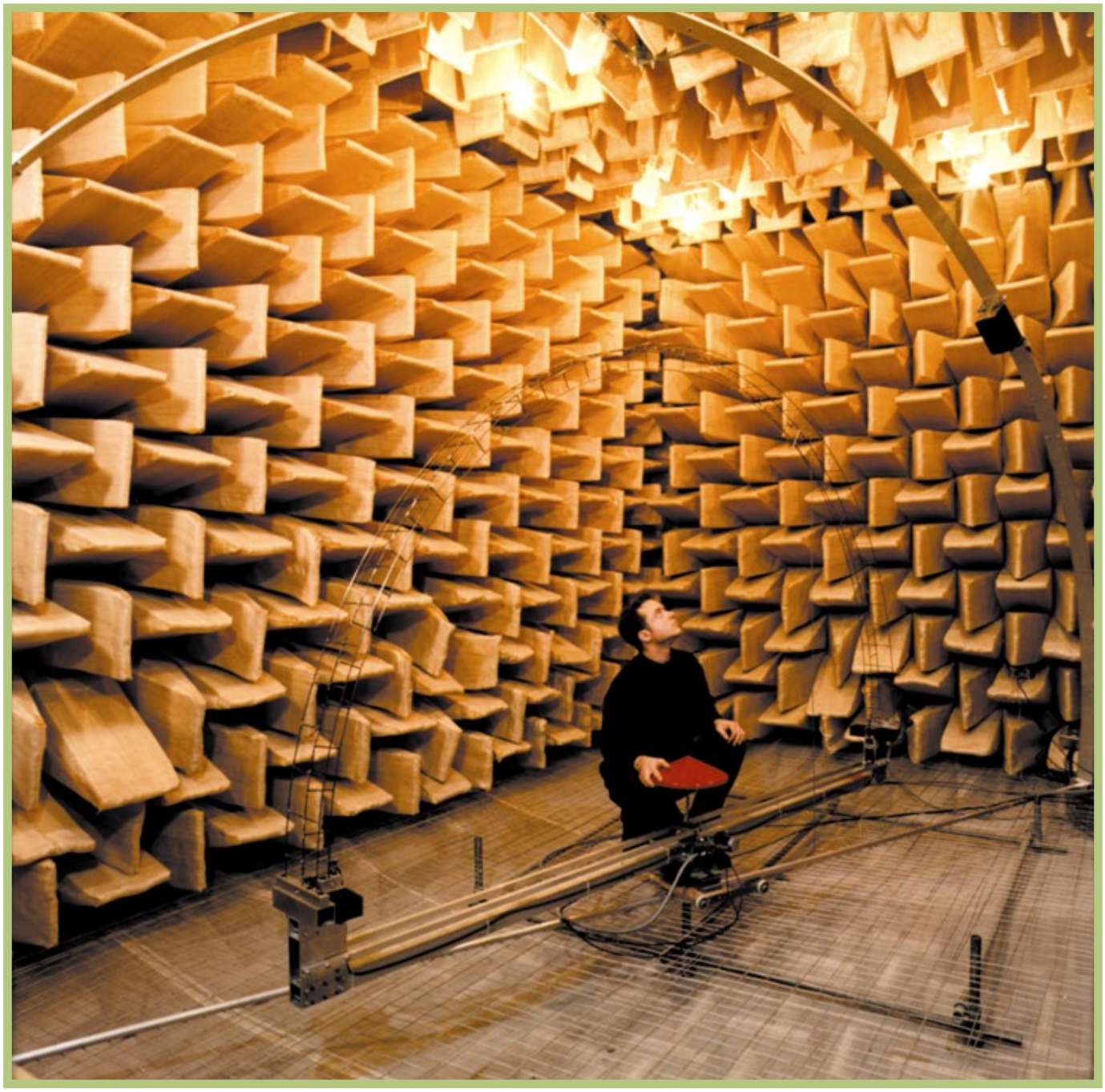
When sound hits the walls, most of it is absorbed and any that is reflected bounces around in the V-shaped gaps between the wedges, instead of back towards your ears.

The room seems silent to the human ear, in fact the loudest things you will hear are your tummy rumbling or your blood pumping around your body.

This kind of room is ideal for testing noisy equipment like speakers and there are even special rooms made to test aircraft engine noise.

An Anechoic Chamber is perfect for when you need absolute silence, but some people find the total lack of noise a bit spooky and have to leave!

Credit: wikimedia



Looking at the anechoic chamber, you can see why people have made homemade sound proofing with egg boxes. While egg boxes might help reduce reflected sound inside a room, the cardboard is too thin to completely stop your noise from reaching your neighbours.

Explore more!

Try visiting your local park at different times of the year. You'll probably find it's busier in summer, so it's likely to be more noisy. But at that time of year, all the trees have their leaves, so there are more soft surfaces to absorb the sound. If your park has lots of **deciduous** (say *dee-sid-u-us*) trees, which lose their leaves in winter, you might find your park becomes more noisy with less soft material to absorb the sound.

Try shouting in each different room of your home. Which has the fewest echoes? Can you explain why?

Explore Shadows and Create a Fantastic Shadow Beast!

Have you ever played around with light and shadows? Use what you discover to make some shadow art.

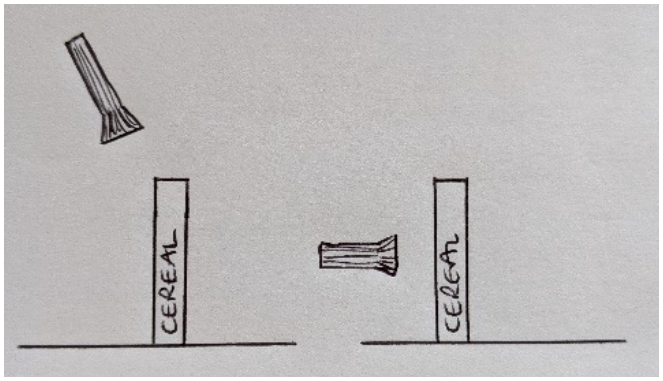
Before you start

Take care if you are using breakable objects!

You will need
- Torch or desk light
- Drinking glass
- Thin supermarket bag
- Cereal box

What to do

1. Use the torch to make shadows using the glass, supermarket bag and cereal box. What do you see? Which object makes the darkest shadow? Can you think why?



2. Put the cereal box on the table and try moving the torch around it. Is the shadow different when you shine from above compared to the side?

3. Try moving the torch far away or close-up – what does that do to the shadow?

How does it work?

The torch or desk light is called a **light source** (say *sor-ss*). That's just something which makes light. Other light sources include lightbulbs, candles and the Sun. The Moon reflects light from the Sun, so it's not really a light source, but you can still use it to make excellent shadows!

Did you notice how the glass hardly made a shadow at all? We describe a clear glass as **transparent** (say *trans-pah-rent*) because it lets all the light through. Some drinking glasses make a slight shadow because there are air bubbles and swirls in the glass. A glass window is usually fully transparent.

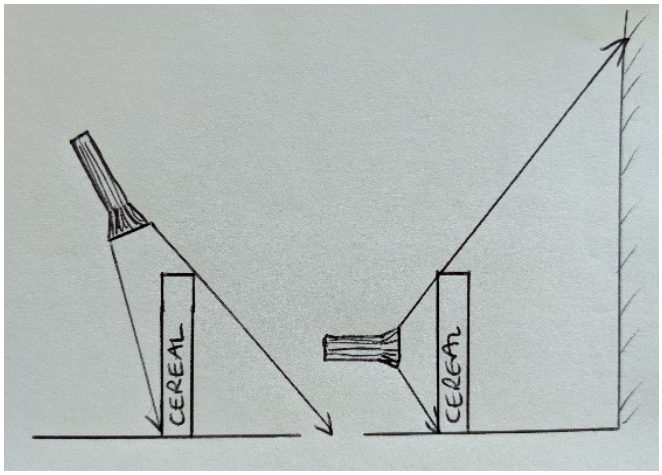
A thin supermarket bag is described as **translucent** (say *trans-loo-sent*). It lets some light through, so it's shadow has medium darkness.

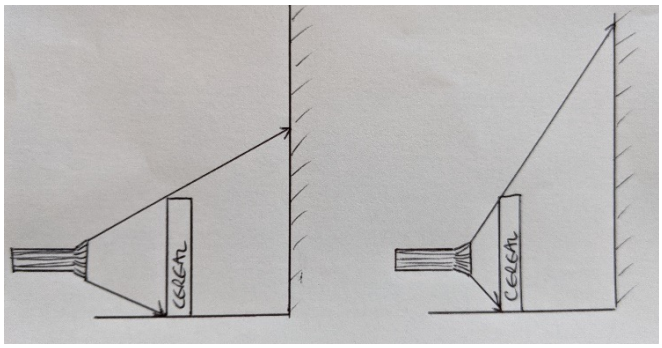
A cereal box is **opaque** (say *oh-pay-cuh*), it blocks out all of the light. That makes a dark shadow. Your body doesn't let any light through either, which is why you can create shadow puppets with your hands.

Did you notice that the shadows were the same shape as the thing which made them? This is because light travels in straight lines.

When you put your torch up high, you should have seen the shadow get shorter. But longer when you put the torch down lower. You can see how the cereal box makes the shadow in these pictures.

You might have seen this with shadows outdoors. When the sun is overhead in the middle of the day, you have a really short shadow. In the early morning and evening, when the sun is low in the sky, you get a much longer shadow!





When you move the torch close to the cereal box, you get a bigger shadow than if the torch is far from the box. You can see how it works in this picture.

Now, it's time to use what you have discovered about shadows to create a Fantastic Shadow Beast!

What to do

1. Think about the shape of the creature you are going to make. If it has spines on its back you are going to need something spiky. If it has a curly tail, you will need a curved object.

2. Collect your materials together. You can use sunlight or a lightbulb to create your beast!

   This Fantastic Shadow Beast needs some spice jars, a shoe, a water pistol and a curvy elephant trunk from a game.

3. Build your beast! Be patient - it can take quite a while to get it right. You'll probably need to take it apart and rebuild it!

4. Ta da! Meet Nova, the shadow dog – she looks quite like the real-life version!

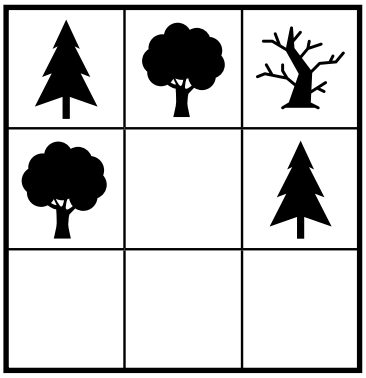
Explore more!

Next time you are out walking on a sunny day, try building a Fantastic Shadow Beast using stones, sticks and leaves which you find. You could even use the shadow of a bush and use your own body to add arms and legs.

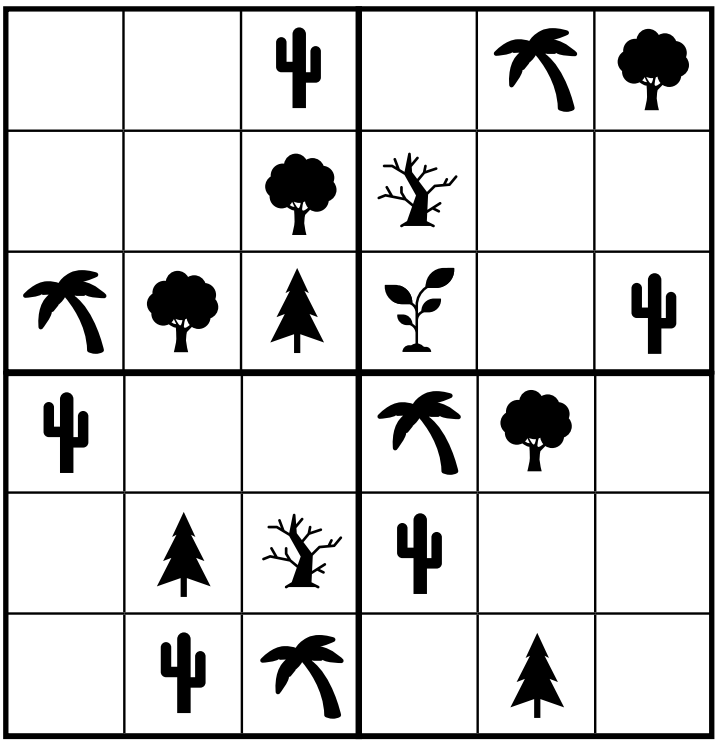
Try creating a Fantastic Shadow Beast at home, using the light in your bedroom or living room.

Shadow Sudoku

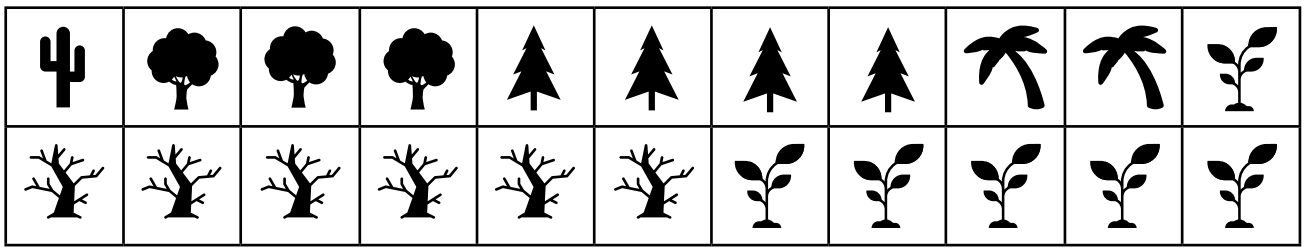
In sudoku, each number or image appears once in each row (line across) and once in each column (line down).Can you complete the grid of tree shadows? Try starting in a line with only one shadow missing. You can print out this sheet and cut out the counters at the bottom of the page, or you can draw the trees in for yourself!



Now try this one! To make it a bit easier, the grid is divided into boxes of six. Each shadow appears once in the box of six, once in each column and once in each row. Answers on page 41

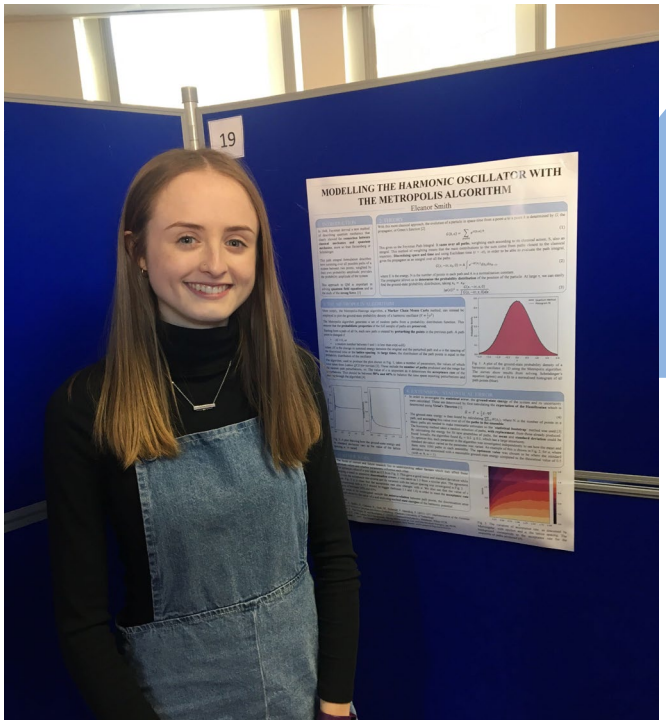


Counters to cut out and use:



Leaving the Ground

Credit: Elle smith



Meet an Environmental Software Developer:

Elle Smith

What do you do?

I'm a software developer – I write computer code that helps people find and use data relating to the climate, atmosphere and environment. I am based at the Centre for Environmental Data Analysis in Oxfordshire, part of STFC RAL Space.

Where did you grow up?

The Wirral, North West England

Which three words describe you?

Thoughtful, friendly, organised

How did you get where you are now?

I decided to study Physics at University after I enjoyed it during my GCSEs and A Levels. At University my favourite topics looked at the environment and climate. I also really enjoyed the projects I did where we had to write code. I put both of those things together and applied for a job writing code to work with environmental data!

What job did you want to do when you were at primary school? What changed your mind to study physics?

I really liked art at school and wanted to be a fashion designer. I decided to continue with Physics instead as I started to enjoy the maths and facts of Physics more than the creativity of designing. However, I do need creativity in my job now, so I have the best of both worlds.

What kind of things do you do in your job?

My days are spent working on different projects. One is a website and the other is a service that helps scientists get the climate data they need to do their research.

On a normal day, I spend some time writing code to add something new or fix a problem with my software. I also spend some time with my team, getting help or discussing what we are going to do next.

Tell me three skills which your job needs

Problem solving, team working, attention to detail

What's the best thing about your job?

I get to work with lots of interesting people! I also learn new stuff every day, this could be from talking to people, looking at their work or by attending a talk that they give.

How do you think your job will change in the future?

There will be more and more climate data in the future, we already have the challenge of how to store it because there is so much! People like me will have to come up with better ways for scientists to be able to find and use all of this data.

Which of the skills you learned when studying physics are most useful in your job?

When I was studying Physics, I learnt how to solve problems using code. This is definitely the skill I use the most now!

What do you like to do in your spare time?

In my spare time I like to run. Running helps me switch my brain into 'relax' mode after work. I also love cooking for my friends and family. It's great when I see them enjoying the food that I have prepared for them.

Do you have any pets?

My family has two dogs, they are called Fred and Stan. I also recently got a kitten who's called Lentil, he's only 6 months old and is very cute!

What is the best piece of advice you have ever been given?

Even if you're not, act confident and eventually you will be confident without having to act.

Credit: Elle Smith

Make a Catapult!

Catapults are great fun for flinging things across the room! This simple design is made with paper and sticky tape.

Before you start

Take care when using scissors!

You will need

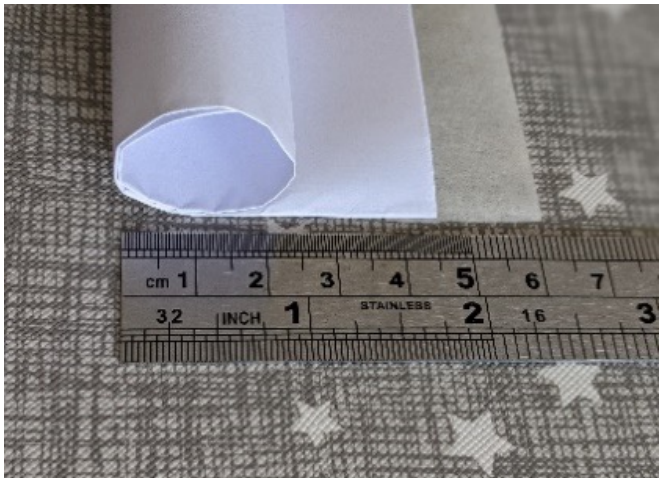
- 8 x A5 (that's half of A4!) paper
- Sticky tape
- Scissors
- Helper for sticking things

Optional

- Tape measure

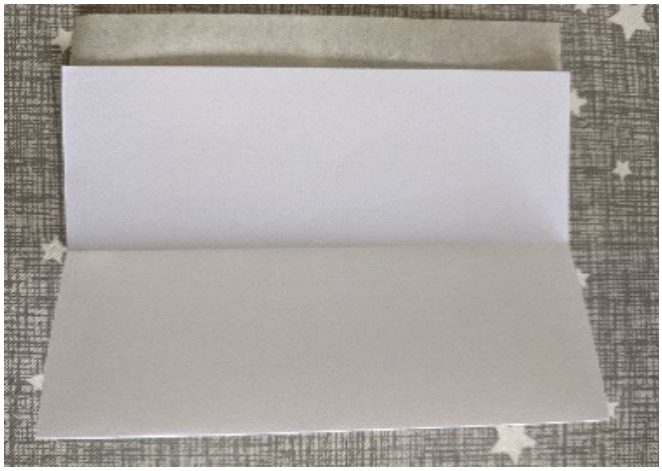
What to do

1. Take a piece of A5 paper and fold it in half so the two short edges are touching. Put a piece of sticky tape along the short edge of this.



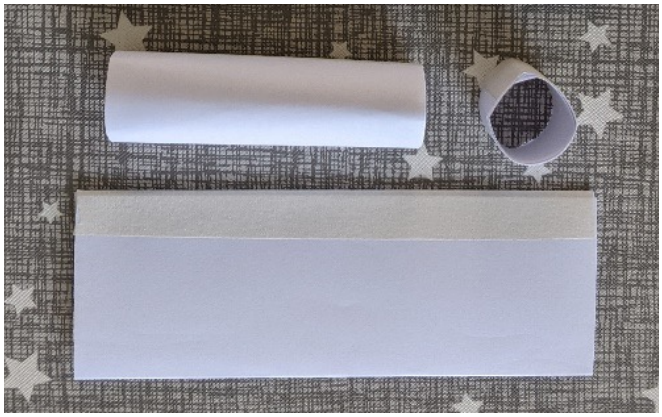
2. Turn the paper so the sticky side of the tape is upwards. Roll the paper to make a tube 2-3cm across. When you reach the sticky tape, it should easily stick in place. Press the tape down to stick it properly.

3. Make two more tubes in exactly the same way.

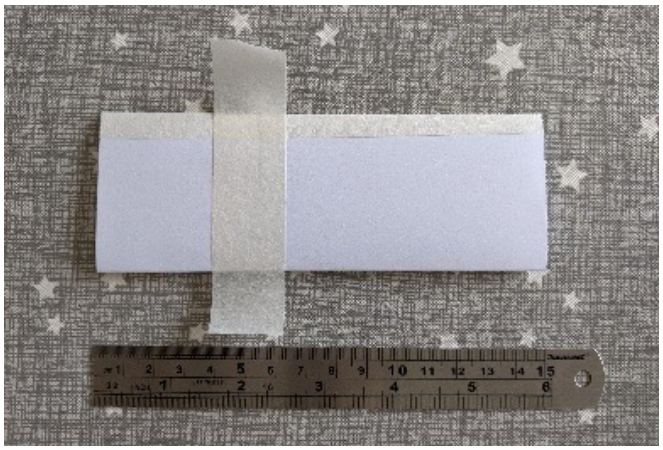


4. Now fold another piece of paper in half, so that the short edge touches the short edge. Then fold it in half again in the same direction. Open out the second fold and place sticky tape along the unfolded edge, then use this to stick all the open edges together. This is the beam of the catapult.

5. Repeat steps 1-4 to make two more sets.

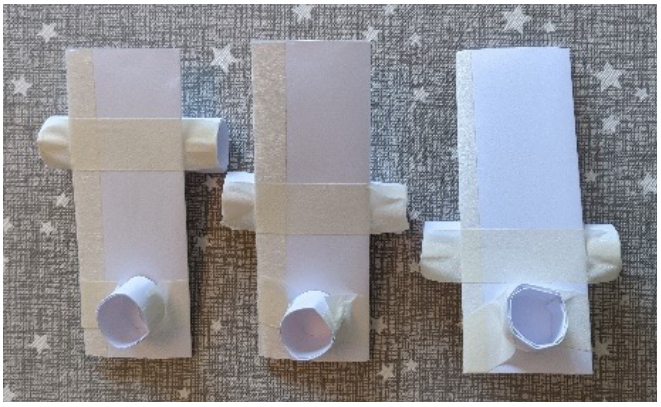


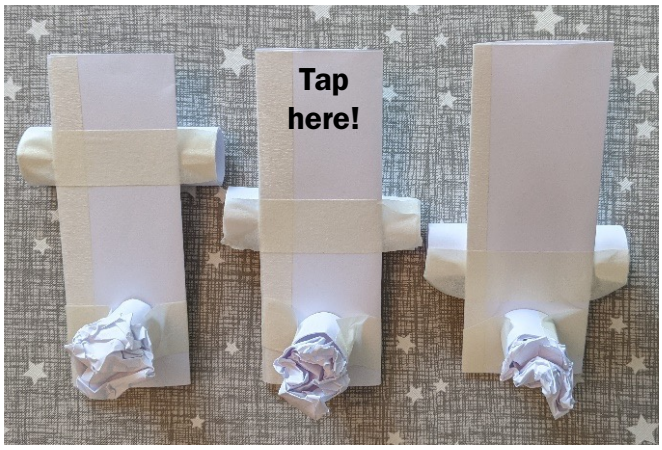
6. Cut a 2cm long section from each tube. You should now have three sets like the picture above.



7. Put a line of tape across one of the beams, 5cm from the left-hand side. Make sure there is a little over-hanging tape. Use the tape to stick the beam onto a long tube. This will make a little seesaw!

8. Stick a short tube about 2cm from the left-hand side. This will hold your missile. Your first catapult is complete!





9. Now make the other two catapults. You will need to make the strip of tape on the beam at 7.5cm from the left-hand side on one, and 10cm on the other. Always stick the missile holder 2cm from the left-hand side. This will give you three different catapults – notice how the empty ends are all different heights.

10. Take the last two pieces of paper and fold them short edge to short edge. Cut them in half along the fold. Scrunch each piece into a ball – this will be a missile! Rest the missile on top of the missile holder, do not push it in. Your catapults are ready for action!

11. To make the catapults work, tap down really hard on the edge of the empty end. Watch your missile fly!

12. Can you work out which catapult can fling the missile the greatest distance? Line up your catapults, so all the missile holders are in a line. Use the same size tap for each catapult and see how far the missile travels. Which one is best?

Think like a scientist:

- Try making a prediction about which missile will go furthest
- What measurements would you take to find out which design is the best?
- How can you try and make it a fair test?

How does it work?

Your catapult is actually a simple machine called a **lever** (say *lee-ver*). It has two main parts: the **beam,** and the tube it is balanced on, which is called the **fulcrum.** It looks just like a wonky seesaw. You are using it to move the paper, which is our missile.

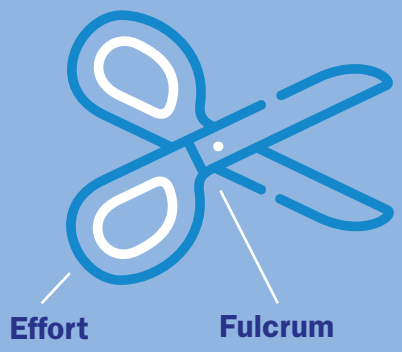
When you tap on the empty end, your push is a downwards force called the **effort**. This effort makes the empty end go down and the missile end goes up because the whole beam tilts at the fulcrum (tube).

So which catapult made the missile fly the greatest distance?

You might find that the catapult with the longest distance between the fulcrum and the missile was best. With this design, when you launch, your hand moves the effort-end down the shortest distance and sends the missile-end up the largest distance. The advantage here is that you are launching the paper missile the fastest out of the three designs.

Levers aren't just useful for sending paper flying across the room! You will have used them almost every day. From opening a door, using scissors or even just nodding your head – levers are everywhere.

Explore more!



Try spotting more everyday levers, what are they used for? Can you label the effort and fulcrum like on our scissors?

Can you build a bigger version of the catapult with a longer beam? You'll need to use cereal box card or more layers of paper to stop the beam from bending.

Can you have a space career in the UK?

It might surprise you that the UK has a booming Space Industry! There are likely to be around 30,000 more space industry jobs in the UK by 2030 – how old will you be then?

There are lots of different jobs too – from hands-on building of spacecraft to managing missions from a control centre. Let's have a look at a few:

SPACECRAFT OPERATORS – A spacecraft needs a ground control team whether there are humans on board or not. Operators are based Mission Control and work as a team to make sure everything happens when it should. They need to be calm, quick thinkers to solve any problems which might happen.

LAWYERS – Space Law exists! Specialist lawyers deal with the rules around space travel and our use of space. They help to make sure space is protected from human pollution and write the instructions for what to do if astronauts become stranded in space.

MEDICS – It takes a wide range of doctors and scientists to keep astronauts healthy. Many are involved in researching the effects of space on the human body.

PSYCHOLOGISTS help with the astronaut's mental health through selection and training. They also support them and their families during and after missions. What psychologists learn now will be really important for long crewed missions into the Solar System.

PROJECT MANAGERS – A space mission is a big project! A manager is someone who makes sure everyone works together as a team to complete a project on time and without spending too much money!

EDUCATORS share what we have learned and what is happening in the space industry. They work with school children and the wider public.

POLICY MAKERS work out what we should be doing in space and they help to make the laws governing it.

CODERS – These scientists use data from satellites, to understand more about our planet (read about Elle, an Environmental Software Developer (on page 30,). Coding is a key part of making space missions happen – from start to finish.

TECHNICIANS build and test spacecraft, robots and equipment. It's a hands-on job for people who enjoy problem solving and have good attention to detail.

ACCOUNTANTS raise the money and make sure it is properly spent.

PATENT ATTORNEYS protect the ideas of scientists, inventors and engineers , which help to get things to space.

RESEARCHERS try to learn more about space. They might investigate out how to make space travel safer and more efficient, or work out the next mission to go on. Some researchers are planetary scientists who have a deep knowledge of a single planet or Saturn's many moons…while others might be learning more about the Big Bang and everything since!

ASTRONAUTS – last but not least, although it is rare, it is possible to be a British Astronaut! Helen Sharman and Tim Peake have spent time in space, but now that commercial space travel looks possible – who knows if you could be next?!

Learn more about careers in the space industry at **https://spacecareers.uk/**

Mission Control when the SpaceX Dragon crew docked with the International Space Station (ISS) and joined the crew, May 2020

Rocket Design Challenge

How high can you make your paper rocket fly?

Before you start

Take care when using scissors and always point the rocket away from people and pets.

You will need

- Paper (we used A5, that's half A4)
- Sticky tape
- Scissors
- Empty plastic milk bottle (no lid needed, washed!)
- Toilet roll inner tube

Optional

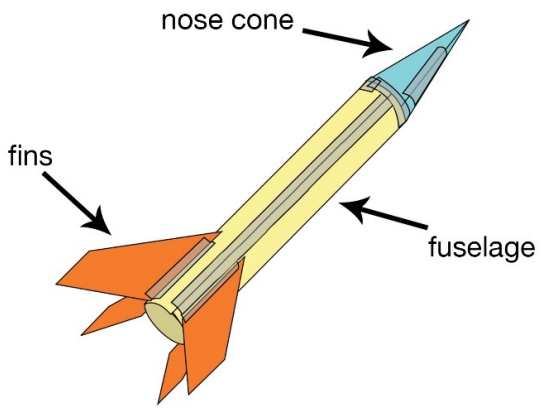
- Pens for decorating
- More paper
- Pencil
- Tape measure

How do rockets work?

Rockets have launched spacecraft to every planet in the solar system and even sent humans to the Moon, but what is the science behind a rocket launch?

To get something moving there needs to be an **unbalanced force,** this is when the forces in one direction are bigger than the forces in the opposite one. For a rocket launch the forces pushing up need to be bigger than the forces pulling down. Find out more about this in our rocket balloon experiment **iop.org/explore-physics/at-home/episode-7-rocket-balloon**

For each mission there are teams people in the **space industry** dedicated to perfecting the design of that particular rocket. Your challenge is to perfect the design of a milk bottle rocket, to send it flying as high as you can. There are three main parts to think about:



Courtesy NASA/JPL-Caltech

- **Fuselage** (say *fyoo-sil-ahj*) – main part of the rocket
- **Fins** – helps keep the side-to-side forces balanced and send the rocket straight up
- **Nose cone** – helps the rocket pierce through the air, reducing a force called **air resistance.** (which always pulls in the opposite direction to the one the rocket is moving in)

Add, test, tweak and improve the shape and size of each part until you have reached the maximum launch height!

What to do

First explore the launcher:

Put the bottle on the table in front of you and put your face over the opening. Use your hands to press REALLY quickly on both sides at the same time. What happens? Do you feel a rush of air coming out? Practise this motion, pushing your hands together as fast as you can.

Now try our basic fuselage design:

1. Put a line of sticky tape along the short edge of the paper.

2. Put the sticky surface of the tape facing upwards, then put the toilet roll tube on the other short edge of the paper. Make sure it hangs over the edge by about 1cm.

3. Roll the paper around the tube, not too tightly or it will be hard to take the tube out! When you reach the end, the sticky tape should stick it down. Press it with your fingers for a good seal.

4. Remove the tube and now you have the **fuselage** – the body of the rocket.

5. Fold over and tape up one end of your fuselage to seal it up. Put the open end of the fuselage over the milk bottle top.

6. LAUNCH (countdown optional). Make sure you aren't leaning over the bottle whilst you do this!

How does it work?

The milk bottle is filled with air molecules. They're whizzing about, crashing into each other and the insides of the bottle, pushing off anything they can bounce off. When you squish the milk bottle, you are making the bottle smaller, so the molecules get pushed out of the top, which is the rush of air you could feel when you tried it earlier.

The upward moving air molecules rush into the rocket and crash into the top of the fuselage. If you squish the bottle fast enough, this upwards force is big enough to overcome the force of gravity pulling the rocket down so the fuselage flies upwards into the sky!

Once it leaves the launcher, the rocket has no power, so gravity starts to pull it back downwards very quickly!

Explore more!

What happens if you add a nose cone?

What happens if you add fins?

What happens if you use a different sized bottle?

Does the size of your squeeze matter – or the speed that you do it?

What happens if you use thin newspaper or cereal box card to make your rocket? Will it still launch?

Draw your final design here:

What is your maximum height?

……..

Space Mythbuster!

A myth is a story which might be believed by lots of people, but which isn't actually true. There are lots of myths about space – can you work out which ones are true and which are false?

See page 42 for the answers

1. **The Sun is a ball of fire**

   TRUE OR FALSE

2. **A weekend on Venus lasts nearly 500 Earth days**

   TRUE OR FALSE

3. **The Sun is yellow**

   TRUE OR FALSE

4. **You can see the Great Wall of China from Space**

   TRUE OR FALSE

5. **The Moon is cold**

   TRUE OR FALSE

6. **If you dropped a piece of toast on the Moon it would just float away into space (mmmm…space toast!)**

   TRUE OR FALSE

7. **Saturn could float in a bath (if the bath was big enough!)**

   TRUE OR FALSE

8. **The fastest winds in the solar system are found in tornadoes here on the Earth**

   TRUE OR FALSE

9. **All the known asteroids in the Solar System are made of less stuff than the Moon**

   TRUE OR FALSE

10. **If you could fly to the Moon in a commercial aeroplane, it would take about a week**

    TRUE OR FALSE

Exploring Our World

The Big Quiz!

Have you enjoyed discovering new things about our world? Let's see what you remember with The BIG Quiz!

1. **Would toast float on the moon?**
2. **What is the name of the ocean current which keeps the UK warm?**
3. **What is another name for the middle of a seesaw, where the beam pivots?**
4. **What is buoyancy?**
5. **What is the name of the equipment which helps us to see sound waves?**
6. **What is the name of the shape made by the drop of food colouring in the water?**
7. **Can you make a shadow with an opaque object, like a book?**
8. **What is the name of the force which pulls us down to Earth?**
9. **Does Space Law exist?**
10. **What is the name of the special silent room where all sound is absorbed?**
11. **What is the name of the force which stops things slipping past each other?**
12. **When you squash an air bubble, do you make it more dense or less dense?**
13. **Which word do we use to describe how high or low a musical note is?**
14. **What is the speed of sound in air?**
15. **What is the name of Elle Smith's kitten?**

Now turn to page 43 for the answers!

Answers:

Wordsearch

T	W	I	W	B	D	I	F	F	U	S	I	O	N	S	B
E	H	F	T	U	N	I	P	E	S	I	O	N	O	A	O
M	A	L	C	O	R	S	P	N	R	C	I	R	E	L	A
P	L	O	W	Y	D	E	N	S	E	S	K	E	E	T	T
C	E	A	C	E	E	L	S	E	P	H	Y	S	I	C	S
I	F	T	U	E	S	S	I	P	R	O	N	E	T	D	Y
R	S	K	R	Y	A	I	F	E	E	C	A	A	W	A	C
C	O	R	R	Y	O	N	G	S	S	T	U	R	E	S	N
U	F	A	E	F	F	K	O	G	S	O	T	C	A	H	A
L	I	G	N	D	A	S	H	G	U	K	A	H	K	I	Y
A	S	C	T	C	O	O	L	P	R	E	S	S	I	R	O
T	H	S	H	I	P	F	A	B	E	A	W	I	S	H	U
I	D	I	F	F	O	D	I	L	G	S	P	H	I	T	B
O	K	W	A	S	I	W	A	T	E	R	E	H	S	O	E
N	I	H	T	E	M	P	E	R	A	T	U	R	E	P	T
O	C	E	E	N	O	P	H	B	A	T	H	E	I	R	S

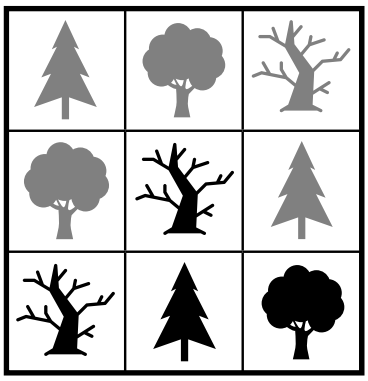
Spaghetti puzzle

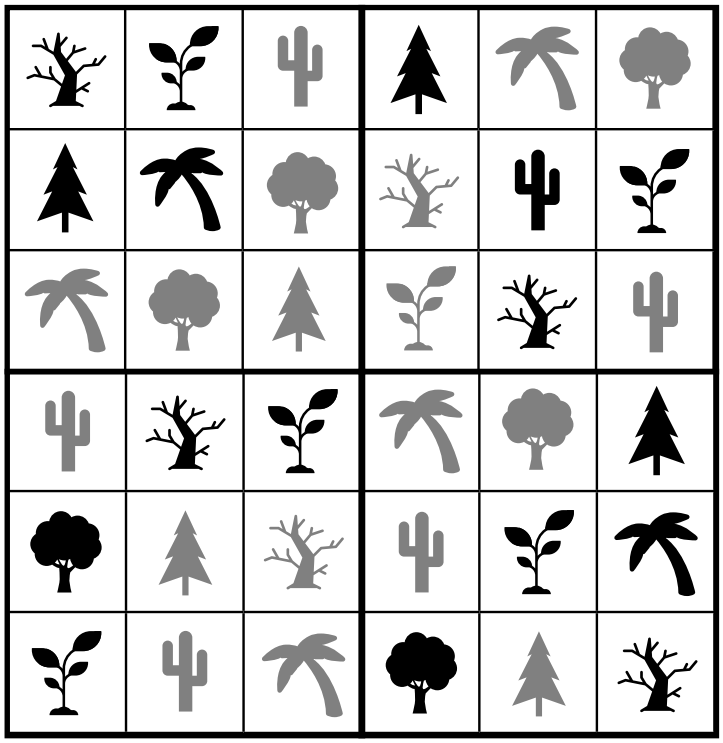
mechanical natural natural mechanical natural mechanical

The dog does not make a mechanical sound – unless it's K9 from Dr Who!

Answers:

Shadow Sudoku





Rocket Hunt!

There are 8 rockets hidden through out the booklet.
You can find them on pages: 9, 11, 17, 20, 22, 28, 35, 37

Space Mythbuster Answers

1. The Sun is a ball of fire

FALSE

Fire is a chemical reaction where fuel is burned in oxygen. The heat from the Sun is made by nuclear reactions in its core (middle). Here, hydrogen atoms join together to make helium atoms under intense pressure.

2. A weekend on Venus lasts nearly 500 Earth days

TRUE

It takes Venus about 243 Earth days to rotate (turn around). So, a two-day Venusian weekend would last (2 x 243 =) 486 days – that's longer than a whole Earth year.

3. The Sun is yellow

FALSE

An astronaut will tell you the Sun looks quite white from space! Space photos are often altered to give the Sun the yellow colour we Earthlings expect. So why do we think it's yellow?

White light from the Sun is made from the colours of the visible spectrum, which we can see revealed in a rainbow. Standing on Earth, we are surrounded by the gases which make up our atmosphere. When white light enters the atmosphere, it hits the gas molecules and gets knocked off course or scattered. The blue end of the spectrum is scattered more than the rest, so the sky looks blue. With lots of the blue light removed from sunlight, the Sun looks more yellow to us on Earth. Please remember never to look directly at the Sun – it can damage your eyes.

4. You can see the Great Wall of China from Space

TRUE-ISH….

It depends what you call space! From the Moon (239 000 miles or 384 000 km away), you can just about see land, sea and the glow of night time lights. The International Space Station is about 250 miles (400km) above the Earth. From there you can see the line of the Great Wall of China and objects over about 115m diameter – so you can see lots of lakes. The Kármán line is often used to mark where space starts – it is 62 miles (100km) above Earth. From there you should be able to pick out a large building like Wembley Stadium!

5. The Moon is cold

TRUE AND FALSE!

In the total darkness of the Hermite Crater, the temperature was measured as -250°C. That's much colder than Earth's coldest record of -94.7°C in Antarctica. However, it's a different story when the Sun shines! Then, without much of an atmosphere for protection, the temperature can reach 127°C. That's hotter than boiling water! It's why astronauts wear reflective white, because it helps to keep them cool in the sun.

6. If you dropped a piece of toast on the Moon it would just float away into space (mmmm… space toast!)

FALSE

The Moon has gravity, so the toast will still fall to the ground but at a slower speed than on Earth. The Moon has less mass (stuff it's made out of) than the Earth, so it has less gravity. It's about one sixth of what we feel on Earth…but that does mean you could jump six times higher on the Moon!

7. Saturn could float in a bath (if the bath was big enough!)

TRUE

Saturn is the only planet in our Solar System that is less dense than water. See the Make a Diving Oceanographer activity for more about density and floating.

8. The fastest winds in the solar system are found in tornadoes here on the Earth

FALSE

Neptune has the fastest winds in the Solar System. They can reach a top speed of 2,575 kilometers per hour, that's about 1,600 miles per hour… or more than twice the speed of sound which we talked about in The art (and science!) of finding peace and quiet

9. All the known asteroids in the Solar System are made of less stuff than the Moon

TRUE

Incredibly, if we could put them all together, the total mass would be less than one tenth of the Moon! They take up so much space because they are really spread out. Asteroid belts don't look as rocky as they do in the movies, but to show the truth would be much less exciting.

10. If you could fly to the Moon in a commercial aeroplane, it would take about a week.

FALSE

If you could fly a Boeing 747 at full speed to the Moon, it would take about 17 days. In 1969, the Apollo 11 moon landing mission took 76 hours, that's just three-and-a-bit days!

What have you Discovered? Answers

The Big Quiz!

How did you do?

1. **Would toast float on the moon?**

   No, the moon has gravity which would pull it down (Space Mythbusters)

2. **What is the name of the ocean current which keeps the UK warm?**

   North Atlantic Current (Role of Ocean Currents in Keeping the UK warm)

3. **What is another name for the middle of a seesaw, where the beam pivots?**

   Fulcrum (Make a catapult)

4. **What is buoyancy?**

   Floatiness! (Make a Diving Oceanographer)

5. **What is the name of the equipment which helps us to see sound waves?**

   Oscilloscope (Exploring the British Library Sound Archive)

6. **What is the name of the shape made by the drop of food colouring in the water?**

   Vortex ring (Wiggly Water)

7. **Can you make a shadow with an opaque object, like a book?**

   Yes! Something opaque completely blocks the light (Magnificent Shadow Beast)

8. **What is the name of the force which pulls us down to Earth?**

   Gravity (Make a Rocket)

9. **Does Space Law exist?**

   Yes! It is made by humans and controls what we do in space. We're not sure about other civilisations….(Can you have a space career in the UK?)

10. **What is the name of the special silent room where all sound is absorbed?**

    Anechoic chamber (The Art (and science) of Finding Peace and Quiet)

11. **What is the name of the force which stops things slipping past each other?**

    Friction (Make a catapult)

12. **When you squash an air bubble, do you make it more dense or less dense?**

    More dense (Make a diving oceanographer)

13. **Which word do we use to describe how high or low a musical note is?**

    Pitch (seeing sound)

14. **What is the speed of sound in air?**

    343 metres per second (The Art (and science) of Finding Peace and Quiet)

15. **What is the name of Elle Smith's kitten?**

    Lentil (Meet an Environmental Software Developer)

How did you do?
Score one point for each right answer

0-5 Oh dear!
6-10 Pretty good!
11-15 Amazing!

What did you think of the pack?
Answer our short survey here, and enter our draw for the chance to win some physics prizes!

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