

# ACTIVITIES FOR STEM CLUBS

This section contains nine activities that each take two or three sessions to complete (assuming each club session will take about 60 minutes, including tidying-up time). Each activity is divided into teacher notes and student worksheets and is aimed primarily at Key Stage 3, but younger and older students can get involved in many of them.

The majority of the materials needed for these activities can be bought cheaply from local shops or educational catalogues.

## Activities for STEM clubs

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Teacher notes

# PHONY PHYSICS

ACTIVITY

# 01

Three sessions suitable for year 7 to year 9.

The experiments are fairly easy to do if you are only using those at the back of this pack, but the level of difficulty is increased as the students have to supply false explanations of the science.

## Before you begin...

Take a look at all of the short experiments in the final section of this pack. Pick which ones you would like to give to your students: depending on the size of your club you will need about five experiments per team, with a minimum of two teams. You will need to supply the necessary materials but, since the short experiments contain full instructions, the students should be able to set up the experiments themselves, perhaps with a little help.

## Session 1

Divide the club into two or more groups, with three to five students in each. The students can take a few minutes to give their teams names. If the club is particularly large and you don't want to have lots of teams, two large teams can split into smaller groups when doing the experiments.

Give each team five short experiments to do. Take a look at the list on the right for some possible combinations. Five experiments is a good number to complete in one session. If they only get through three, that's enough. Keep the teams practising their experiments until they understand the physics, but they must remember to be quiet or they run the risk of another team overhearing.

## Session 2

Each team picks three experiments that they really understand. Now they take time to write a true and false explanation for each of the experiments. Remember: they need to make the false explanation sound as plausible as possible without being true. You may want to put a time limit on this part of the exercise. They may even want to repeat some of the experiments.

Here are some groups of Marvin and Milo experiments that they could use:

#6 Lava lamp	#18 Juice carton sprinkler
#32 Homemade sunset	#19 Balloon rocket
#33 Gripping rice	#27 Singing paperclip trick
#39 Loop the loop	#35 DIY chromatography
#41 Spinning rocket	#36 On a roll
#15 Convection snake	#16 Bouncing balls
#26 Magic apples	#22 Impossible straws
#28 Chicken sounds	#34 Cup trick
#30 Inseparable books	#37 Clumsy catching
#43 Loud lollies	#42 Antigravity Maltesers

## How to get it wrong

1. Getting the science completely wrong is actually pretty hard. It is useful to start by identifying what area of physics the experiment falls into. On their sheet, students will find a list of physics topics. They need to look at each of their experiments and work out which they fall into.
2. The next thing is to work out what the main point of the experiment was. Did something start moving? Did something stop? Was a sound produced? On their sheet they will find a list of these kinds of question that cover many of the short experiments.
3. Finally they need to supply the true physics reason why something like this could happen. On their sheet they will also find a list of alternative incorrect reasons, which they will have to add to a little to make them sound plausible.



Here are some examples for a few of the experiments if they get completely stuck.

### Homemade sunset

**True...** The milk particles in the water don't let light pass straight through. Blue light is scattered more than red, so the blue light is scattered out to the side. The white torch light has lost some blue, so it appears red through the liquid. This is the same reason why the sky is blue and sunsets are red.

**False...** Milk is stored in a frosted bottle in a dark fridge because it reacts with light. When a bright light is shone through milk for a few minutes, it turns a pale blue. This blue liquid then absorbs further blue light and lets only red pass through, which is why the torch appears red.

### Convection snake

**True...** The radiator heats the air around it and the particles spread out. This means that the air is less dense and rises upwards. The rising air pushes on the paper, causing it to spin.

**False...** The shape of the spiral means that it is in unstable equilibrium. The centre of gravity of the spiral is continually trying to fall to its lowest point, which pulls the rest of the spiral with it, making it continually twist and turn.

### Impossible straws

**True...** For the water to be forced into your mouth, the pressure outside your mouth (atmospheric pressure) needs to be greater than the pressure inside. This means that, no matter how much you suck, a straw won't work if air can get into your mouth.

**False...** By having two straws in your mouth (with at least one going into air), the brain is fooled into thinking that your mouth is a nose, with two nostrils. The brain then stops the person from being able to suck enough, preventing choking.

### Gripping rice

**True...** As you push it in, the pencil forces the grains sideways, but they fall back into the gap as you try to pull it out. The rice becomes more and more tightly packed until the friction between the rice and the pencil is so great that you can lift the jar.

**False...** The rice is magnetically attracted to the wooden pencil and to the glass jar. With enough rubbing the magnetic field builds up until it is strong enough to lift the heavy glass jar off the table.

### Balloon rocket

**True...** As the air rushes out of the balloon it pushes back on the balloon, thus propelling it forward.

**False...** As the air comes out of the balloon it becomes lighter and starts to float upwards in the air.

### On a roll

**True...** Rubbing a balloon moves negatively charged electrons from your hair to the balloon's surface. When you hold the balloon close to the can, the negative charge causes the electrons in the can to move away. This leaves a positive charge on the surface of the can. The can is attracted towards the negative charge on the balloon and rolls towards it.

**False...** Rubber is a magnetic material. By rubbing it, you magnetise it by physically moving the atoms so that they all point in one direction. The aluminium drinks can is also magnetic and is attracted to the north pole of the magnetic balloon, just like a magnet is attracted to a metal fridge.

## Session 3

Flip a coin for who goes first. This team performs one of its experiments in front of the other team(s). They can use volunteers from the other team if necessary – particularly useful if someone has to get messy.

Next, two people from the first team read out both the false and true explanations. Can the opposing team tell the difference between true science and their competitors' crackpot theories?

Who will win? Only those who can tell physics from fiction.

# PHONY PHYSICS

Can you tell physics from fiction? Your team will be performing some physics experiments in front of an opposing team. You will give them two explanations of the science that they have just seen, but only one will be right. Will they know which? How will you do when your opponents try to trick you with their false physics?

## Session 1

Start off by trying out a selection of physics experiments. Try as many as you can because your team will need to choose a minimum of three for the final game. Make sure that you understand the physics involved.

## Session 2

Choose three of the experiments you tried out. It might be a good idea to pick the ones that you understand best. Work out which physics topic the experiment involved. This should help you to avoid that topic when coming up with your false explanation.

## Do you know what physics was hidden in your experiments?

### A force?

If something starts to move or stops moving, you are probably looking for a force, but you will need to dig deeper and work out what the force is.

Did something rise or sink, drop or float? (**gravity or buoyancy**).

Did something slow down? (**drag or friction**).

Did something refuse to move? (**friction**).

Did something move through the air, or did air move over something? (**drag**).

Did you need a magnet? (**magnetism**).

Did it involve electrons? (**electricity**).

### Not a force?

If something didn't move or stick then perhaps the experiments can be explained better with some other physics topic.

Did something squash? (**elasticity**).

Did you need a light to see the effect? (**light and colour**).

Did you hear a sound? (**sound and waves**).

Were you dealing with something hot or cold? Did something change from a solid to a liquid, or from a liquid to a gas? (**heat and insulation**).



Working out what topic your experiment fell into is just the start. Now you need to get the science wrong. You could always say that it was magic, but the other team is likely to see through that.

# PHONY PHYSICS

The trick is to make your phony physics sound correct.

Your false explanation will need to describe what happened. Here are some pointers to help you come up with some false physics.

### Question

Why did it start to move?

### Correct Answer

- gravity
- magnetism
- less friction
- static electricity
- difference in pressure
- change of density

### Incorrect answer

- magnetism
- a chemical reaction
- anti-gravity
- magnetism
- difference in gravity
- magnetism

Why didn't it move?

- friction

- gravity, or magnetism

Where did the sound come from?  
object

- something vibrating

- heat stored in the

Why did the object rise up?

- a force acting upwards

- magnetism

What happened when the air or  
water came out?

- the air or water forced  
it forwards

- the object became lighter

Why did something move more or in  
a different direction than expected?

- friction caused it to change  
direction
- it was given an extra push  
or more momentum
- air was pushing against it

- gravity acted in a  
different direction
- there was less friction
- gravity acted in a different  
direction

What made the water behave  
strangely?

- surface tension

- a chemical reaction

Why did the temperature rise?

- something was a good  
conductor

- it reacted to light

### Session 3

After showing the opposing team your experiment you will need two people to read out the explanations – one true and one false. Write down both explanations because you need them to sound the same, and choose your best actor for the false

one – they will need to read it with confidence.

You won't win just by fooling the other team though: you also have to spot their phony physics. Keep your list of physics topics handy and make sure that what you see matches what you hear.

Three sessions suitable for year 5 to year 9.

This activity explores some of the ways to make your rockets go farther and fly higher. Spend one or two sessions trying different rocket and launcher designs before having a competition for the best rocket. After this, you could use the knowledge you've gained to put together a water rocket. Compete against each other or enter the NPL Water Rocket Challenge.

### Before you begin...

Look through the short experiments included in this pack that involve rockets. You'll find Marvin and Milo's #9 (Alka-Seltzer rockets) and #19 (Balloon rocket).

Once you've decided which rockets to make, you'll need to assemble the equipment, including cardboard and sticky tape for launch pads, and paint and paper for decoration. Film canisters can be picked up free from many film-processing shops – they often keep them for such activities.

## Session 1

### Engine design

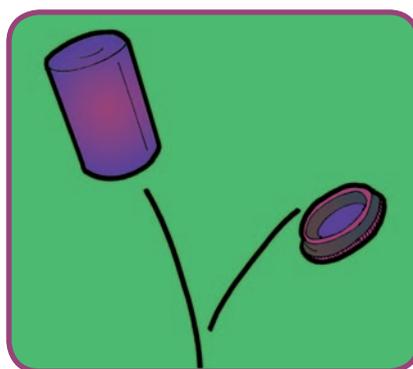
Divide the club into small teams (even teams of two is more fun than making them alone). If everyone is making the same type of rocket, hand out the sheets and let them get on with it. If not, decide which teams are making which rocket – sodium bicarbonate, Alka-Seltzer or (the less messy) balloon rockets.

To start with, the teams should get used to building the rockets and enjoying setting them off. Make sure that they stand well back on launch because the rockets can be messy, and they do involve a hard projectile.

Once the teams have worked out how to make the rocket and, more important, how it works, they may want to move on to the design phase. At this stage they are only looking at the rocket engine – what makes it fly.

### Alka-Seltzer and sodium bicarbonate rockets

The students may be able to improve the force at launch by changing some of the quantities (e.g. more sodium bicarbonate or liquid). They may even want to warm the liquid to get a faster launch and find out if it shoots higher, or break the Alka-Seltzer tablet up (of course, they will need to run to get out of the way). Also, some film canister designs launch more consistently than others.



### Balloon rockets

Students may want to try different types of balloon.

By the end of the session they should be able to make rockets that fly fairly consistently, and have tweaked the design to maximise the launch force.

## Session 2

### Making improvements

As with all rocket design, the purpose is to make the rocket better than everyone else's. Better could mean flying higher, going farther, carrying more weight or just looking more impressive. Varying different superficial features of the rocket can really improve it, and that doesn't just mean painting it red.

### Alka-Seltzer and sodium bicarbonate rockets

The surface that the rocket is launched from affects how it will fly. The students can make launch pads fairly easily with a folded piece of cardboard and some sticky tape. Although 45° might be the best angle for maximum distance, students may find it difficult to balance their rocket like this, so they should experiment with different angles and mechanisms to keep their rocket in place. They can then add fins and a nose cone to make it look more like a rocket. Finally, they can even attach a payload (e.g. coins taped to the side of the canister) to test the force of the launch.

**Balloon rockets**

In this case the string can make a huge difference. Try putting oil or washing-up liquid on it to reduce friction. Carefully attaching the balloon to the straw can ensure that the air comes straight out of the back, thus forcing the balloon forwards.

Once everyone is happy with the design of their engine and exterior, they'll need to make sure that it's ready to go for the next session.

**Session 3**

Each team can have several rockets and they can enter one or more events.

To judge the highest flight the rockets need to be launched at the same time because their rather random flight will make it difficult to compare them if launched separately. In the case of balloon rockets, a vertical string dangling taut from a window makes a perfect vertical challenge.

A distance challenge is easily managed in a playing field or large playground. Launch your rockets several times before you decide the winner.

Of course, you will need a discerning judge to decide who has decorated their rocket the best.

**and beyond...**

[www.npl.co.uk/waterrockets](http://www.npl.co.uk/waterrockets)

If your group is looking for a larger science challenge, try making water rockets. You can hold your own competition or enter the NPL Water Rocket Challenge which is normally held in June.

**What is a water rocket?**

A water rocket is a projectile made from a plastic bottle and is powered by an enormous amount of air pressure.

**How do you make one?**

Balance a 2 litre plastic bottle upside-down outside. Seal it with a cork or rubber bung, and pump water into a thin nozzle through the cork. As the water flows in, the air pressure inside grows until the cork pops out. Water is forced out and downwards, and the rocket flies up, demonstrating Newton's Third Law.

**How do you make a good one?**

Have a look at the NPL website to find out how to improve on the basic design and also understand the physics behind it. To make it fly you'll need to construct a launch pad, add fins, find the balance between the weight of the rocket and the pressure that it can hold and, of course, it will need to be decorated.

**How do you win?**

The longer the rocket stays in the air, the greater the chance of winning, but there may be bonus points for getting it to land in the right place. There are also prizes for design, launch and effort.



# Student worksheet

# ROCKETS

# ACTIVITY

# 02

Can you make a rocket that flies farther and looks better than the rest of your club? In the next few sessions you will be taking a simple rocket design and supercharging it – creating a rocket design superior to all others.

## Session 1

### Rocket engine design

If you want to be a rocket engineer you'll need to become familiar with how rockets work. Follow the instructions to build and launch a series of rockets, taking careful note of how high they go and what distance they travel.

Once you've practised enough so that they launch well each time, you can start making improvements.

### Improvements

**You can't improve on the engine design unless you understand how the rocket works. Ask yourself a few questions:**

- What causes this rocket to launch?
- What gives it the "oomph" to lift off the launch pad?
- Is there a way you can increase the amount of oomph?
- Does making it launch more quickly make it fly higher?

**For sodium bicarbonate and Alka-Seltzer rockets, you may want to change the quantity of liquid or the quantity of solid. How can you make the reaction happen faster? Does this help with the launch?**

**If you are making a balloon rocket you might like to try different types of balloon.**

**Perfect your rocket design and then clean up the mess, ready to start the next session with clean equipment.**

## Session 2



By now you should have perfected the rocket engine, but this isn't the only thing that will affect your rocket's flight.

### Launch pad

If you are making Alka-Seltzer or sodium bicarbonate rockets, it's important to have a solid, flat launch pad to achieve

maximum height. To achieve maximum distance you will need to place the launch pad at an angle.

You can create launch pads from cardboard and sticky tape. Fold a piece of cardboard over and use the sticky tape to hold it in place at the angle you want. You may want to adjust the angle to achieve the maximum distance. It might be difficult to hold your rocket on the launch pad at the angle you want, so experiment with ways of keeping your rocket in place without slowing down its launch.

With a balloon rocket, try making the string more taut and/or more slippery.

### Improving the aerodynamics (and the look)

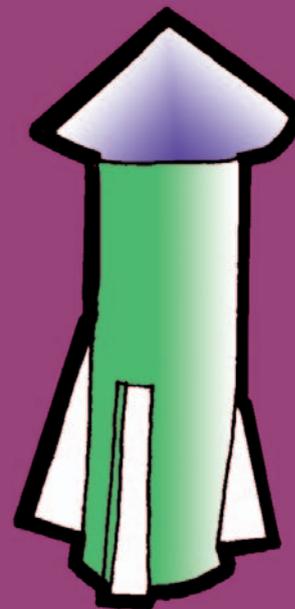
Next you will want to design a cover for your rocket.

### Alka-Seltzer and sodium bicarbonate rockets

Wrap paper round the film canister. This can extend well above the top (technically the bottom) of the film canister. Make a nose cone from a circle of paper. Add fins, and don't forget to give your rocket a name. Admittedly the nose cone and fins are unlikely to give you an aerodynamic advantage, but points may be awarded for how your rocket looks.

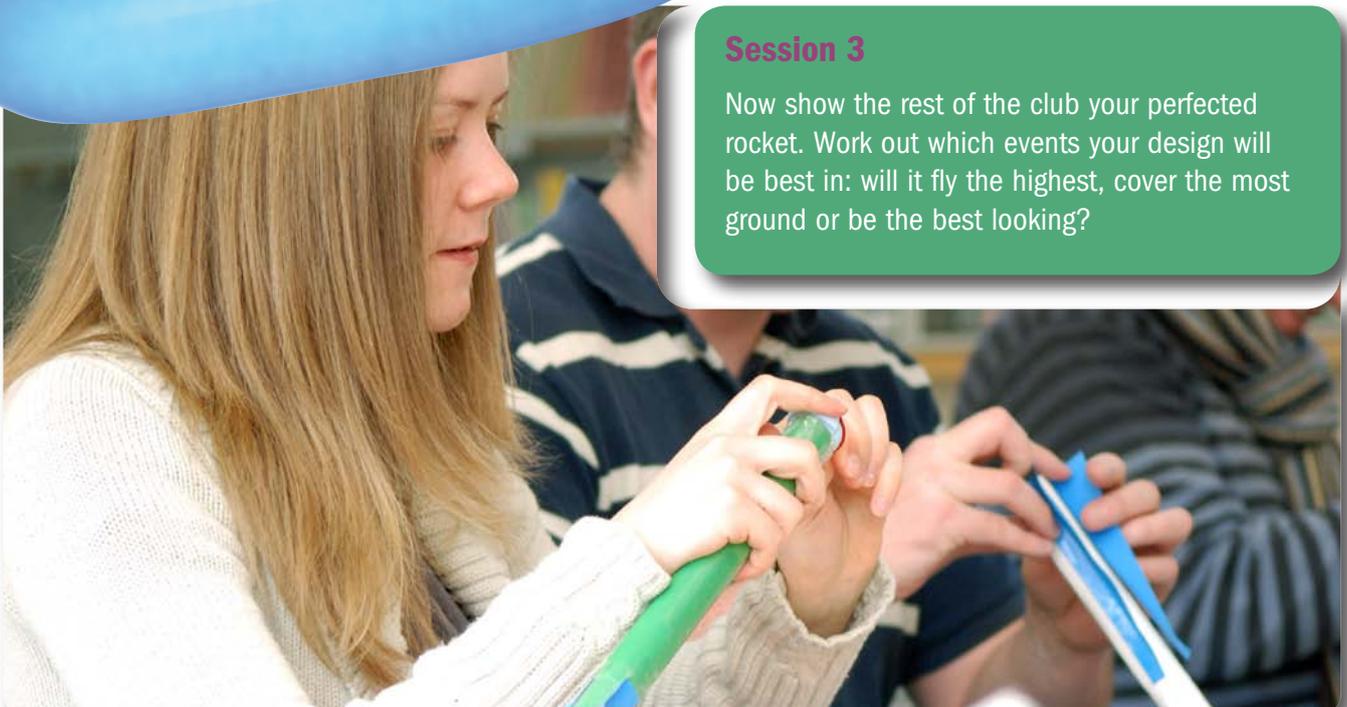
### Balloon rockets

Try decorating your balloon rocket, or write a message that you want your rocket to deliver. What would be the best way to attach it to your rocket?



### Session 3

Now show the rest of the club your perfected rocket. Work out which events your design will be best in: will it fly the highest, cover the most ground or be the best looking?



Three sessions suitable for year 5 to year 9.

Using some of the short experiments included in this pack (or found elsewhere), students will be translating an interesting science experiment into a fantastic science comic strip. You may want to combine forces with some artistic students and teachers in the art department to help to put together the final cartoons. Will they be able to squeeze all of the science in? Working in teams, you can award a prize to the best cartoon.

### Before you begin...

The students can work individually or in teams, and each will need to do a few experiments. They can start with some of the Physics to Go experiments contained in the final section of this pack and then look at the same experiments in Marvin and Milo, or do a selection of the Marvin and Milos experiments to see how the science can be summarised in a very short cartoon.

Next you will want to find some experiments that they can translate into their own cartoon format. Have a look through the ones in this pack and choose those that you think the teams might enjoy doing, or use some of the resources in the "Further information" section of the Introduction to find short experiments online. The students may want to look through these and choose their own, or pick from a selection.

If you're going to make this into a competition, don't let different teams know what the others are doing: half of the fun will be trying to repeat the experiments using only the cartoons.

The following are provided here both in written form as a Physics to Go experiment and as a Marvin and Milo cartoon.

- |                                     |   |
|-------------------------------------|---|
| #6 Marvin and Milo: Lava lamp       | #29 Marvin and Milo: Cartesian ketchup sachet diver |
| #13 Physics to Go: Lava lamp        | #11 Physics to Go: Cartesian diver                  |
| #16 Marvin and Milo: Bouncing balls |   |
| #15 Physics to Go: Extra bounce     |   |



### Session 1

Working individually or in teams, students can do some of the Physics to Go experiments and then repeat them using the Marvin and Milo cartoons, or do a selection of the Marvin and Milo cartoons, noting how few words are needed for the explanation if the pictures are good enough.

By the end of the session they should realise that only the most important information needs to be included in their cartoon.



## Teacher notes

**EXPERIMENTAL  
DESIGN****Sessions 2 and 3**

Give each team one experiment that you have selected for them, or let them choose their own. They'll need to carry out the experiment so that they understand how it works, but they should try not to let others see what they are doing, or those students will have an unfair advantage.

Once they understand their experiments, they need to work out how to make it into a cartoon. There are helpful hints on the students' sheet. This will help them to break it up into useful chunks and then develop characters to explain what's happening. It should take the rest of the session – possibly longer – for them to produce their cartoon.

**Final session**

Make copies of the students' cartoons and get the other teams to repeat the experiments, using only the new cartoons. Each team can give a score out of 10 to the other teams, based on how easy the instructions were to follow, how well the science was explained, and how artistic and amusing the cartoons were. Adding up the scores for each should produce a winner.

Are they particularly brilliant? Send us copies and we may make them into Marvin and Milo cartoons.



# EXPERIMENTAL DESIGN

## ACTIVITY 03

Fancy yourself as an artist? Do you have an idea for your own comic strip? Well, we have the subject matter if you have the talent...

In the next few sessions you will be translating a fascinating physics phenomenon into an even more riveting (and, more important) easy-to-follow cartoon. How do you go about that? Well...



### Session 1

You will be trying out a few experiments. Some will be long and some have already been translated into Marvin and Milo cartoons – short, snappy and enlightening. Note how only the most crucial information is included in the cartoons.

### Sessions 2 and 3

You will have an experiment to do. Make sure it isn't too complicated or there won't be enough room to fit in the full directions and explanation into a cartoon. Do it a few times and make yourself very familiar with it. Make a note of what is important and what isn't.

You might want to think about these things:

- What things did I need to do it? Was there anything that wasn't really necessary?
- Can I break the experiment down into three or four steps? Try the experiment again, this time

following your new instructions to make sure that someone else can repeat it.

- How long does the science explanation have to be? Make sure you only put in the important points – you don't want so many words that you can't see your characters.

You'll then have to come up with one or more characters. Base them on someone you know, or use your imagination. If you have to use a lot of words to explain the experiment and the science behind it, you might need to make your cartoon fairly simple.

### Final session

Now your cartoon will be put to the test. Other members of your club will be given a copy and asked to repeat the experiment following only your instructions.

Did you make a list of everything they needed, and did you miss out any important steps?

Do they understand your explanation of the physics?

Don't forget: even if it all goes horribly wrong, you might still get points for your artistic ability.

# MEDICAL MADNESS

Three to four sessions suitable for years 8 to 9 to build and years 5 to 9 to play.

In this activity the students will be constructing a game using an electrical circuit and a buzzer. Surgeons need to have a steady hand, and so will everyone in your club if they are to build and operate on their own patient.

## Before you begin...

Take a look at Inside Story at [www.insidestory.iop.org](http://www.insidestory.iop.org) to find out about procedures involving some ground-breaking technology. The students' sheet contains instructions for making a game, with a full list of the equipment needed. After a session for research, they should start constructing the game in session 2.

Read through the students' sheet to get an idea of how the game will be put together and the kind of background knowledge that they'll need before they begin.

You will also find information on some anatomy pages specially designed for students. Here are a few:

*The BBC's interactive body - a fantastic place to start, with some obscure organs to place in a human body ([www.bbc.co.uk/science/humanbody/body/index\\_interactivebody.shtml](http://www.bbc.co.uk/science/humanbody/body/index_interactivebody.shtml)).*

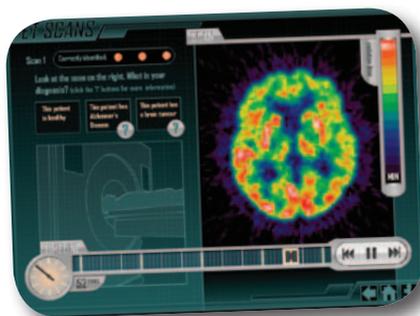
*You can also click through to find out about bones and different organs ([www.bbc.co.uk/science/humanbody/body/factfiles/organs\\_anatomy.shtml](http://www.bbc.co.uk/science/humanbody/body/factfiles/organs_anatomy.shtml)).*

*Anatomy clipart - to help with drawing the trickier organs ([www.classroomclipart.com/cgi-bin/kids/imageFolio.cgi?direct=Science/Anatomy](http://www.classroomclipart.com/cgi-bin/kids/imageFolio.cgi?direct=Science/Anatomy)).*

## Session 1

Let the students have a go at **Inside Story** and have a look at the different procedures that can be performed.

Once they have played all of the games there and had a look at other resources, they'll need to make a list of possible operations and procedures. They'll then need to think about how these can be translated into the game.



Some possible operations are:

- heart and lung transplant – simple removal and replacement of the heart and a lung;
- stem cell insertion – addition of a piece of sticky tape to one of the organs (you'll need to choose which organ needs repairing in this way);
- hip or knee replacement – removal of the joint and substitution for a new one, in exactly the right place, before the patient comes round from the anaesthetic;
- brain surgery – removal of a piece of skull to reveal the brain so that it can be operated on;
- appendectomy – removal of the appendix, once the students have found it;
- colonoscopy – a surgeon may need to biopsy a piece of colon – build a tunnel to make it even more tricky to get the sample out.

Students will also need to look at the MRI scanner at Inside Story to determine which part of the brain will be affected if the patient starts to feel pain. This section of the game will light up, telling students to stop before they cause any damage.

Teacher notes

# MEDICAL MADNESS

## ACTIVITY 04

### Sessions 2 and 3

The full instructions for how to wire up the game are given in the accompanying student sheet. You can either photocopy our drawing of the human body or build a supersize game by tracing round a student lying on a large piece of paper.

If you do this you will need to factor in using a lot more wire (but don't use a larger battery). This way the students get to imagine what it would be like for a surgeon.

### Variations to make it more complex

If students in your club are looking for more of a challenge, they can change the basic design.

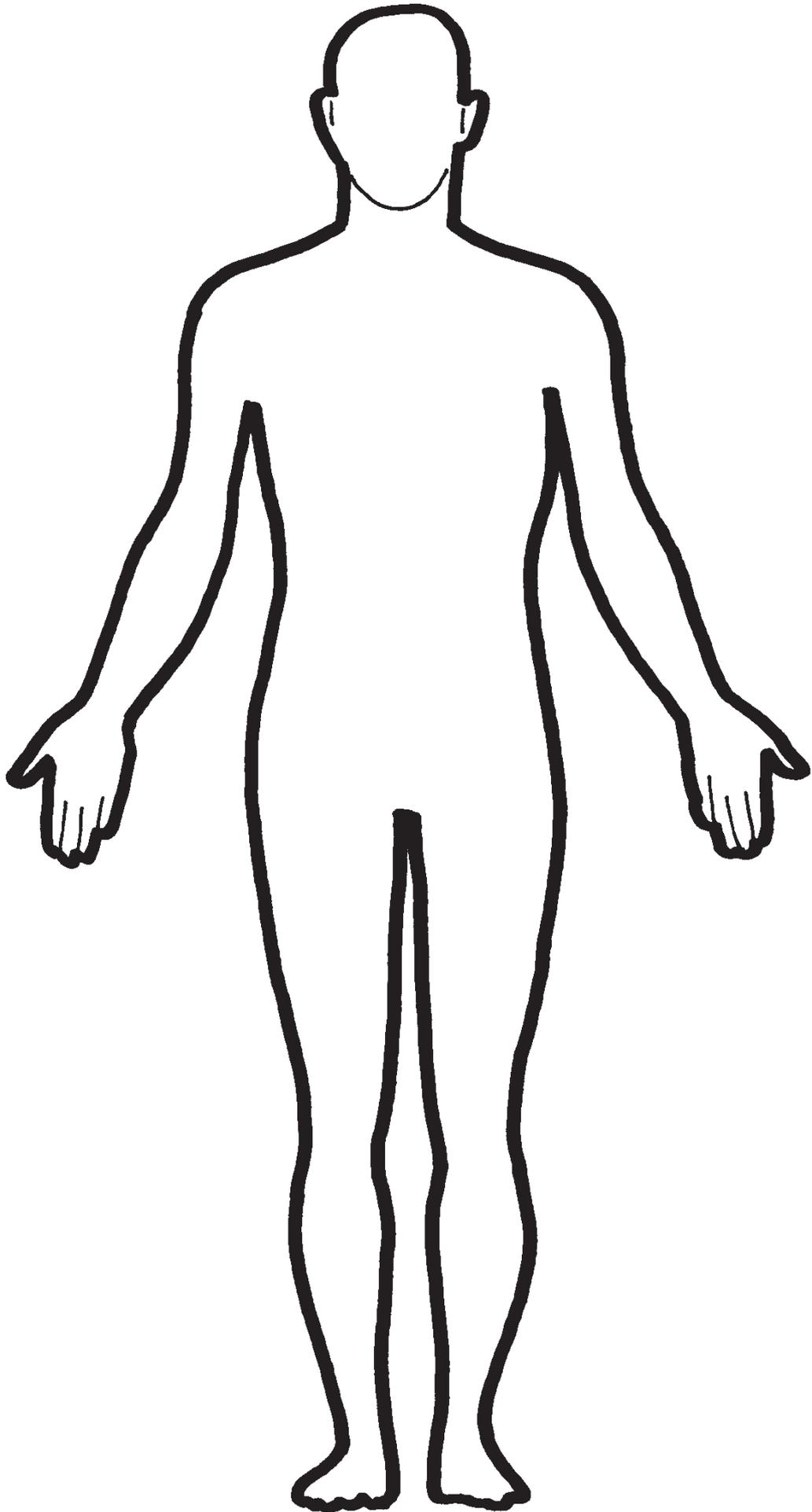
By adding a switch to the circuit, the anaesthetist can switch off the buzzer for a short amount of time, allowing the surgeon to perform the operation. Of course, the surgeon will have to work quickly and carefully or the patient might come round.

Attach a second pair of tweezers in parallel with the first, allowing surgeons to use both hands to remove organs.

### Session 4

Make a list of the different operations that students can perform so that you can pick them randomly, or make your new surgeons perform all of the operations and take a note of how successful they are.





Student worksheet

# MEDICAL MADNESS

## ACTIVITY 04

Have you got a steady hand? How about a stomach for things when they get a little gory? For this you will need both! To put this game together you will need to choose what surgery you want to perform and make your own internal organs.

### Session 1



Have a look at **Inside Story** and use lots of online resources to familiarise yourself with what human internal organs look like and where they are. You will need to start thinking about what operations your patient might need. What about using some cutting edge science, from transplants to stem cell therapy, to battle against some of the most common and deadly diseases faced by humans?

### Sessions 2 and 3

In this session you will be making a game that uses wires instead of a patient's nerves to let you know if you're a bad surgeon. Each organ due for an operation is surrounded by a loop of wire, which is linked to one side of a battery and a buzzer. The tweezers are linked to the other side of the battery. If you touch the wire with your tweezers during surgery you complete the circuit and the buzzer sounds.

If you make the buzzer sound too much, your patient may die and you'll be struck off.

#### Making the board

You will need:

- a buzzer
- a light or LED
- two AA batteries and a battery holder so that the wires can be attached easily
- wire
- metal tweezers
- cardboard - a large piece that can be lifted off the table, some supports and smaller pieces to make the organs
- paper
- sticky tape
- paint
- scissors

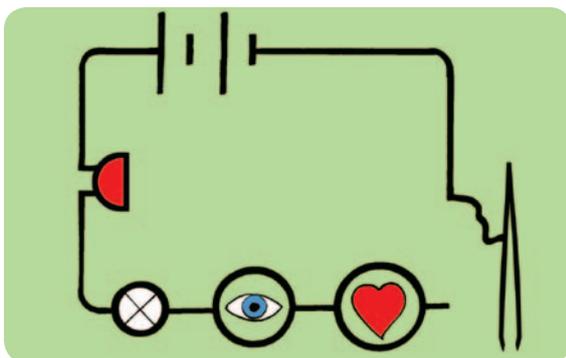
## What to do:

### The patient

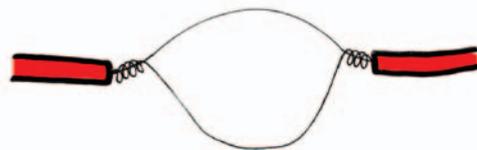
1. Make cardboard cut-outs of the organs that you want to include in your game.
2. Stick the picture of the patient on a sheet of cardboard and mark where the holes will have to be for surgery. Cut out the holes – they need to be just bigger than the organs.
3. Make a hole for the light to flash when the patient feels pain. Check the MRI scan from Inside Story to make sure that your patient's pain centre is in the right place.
4. Paint the patient, being as gory as you like.

### The circuit

5. This is a series circuit with a wire running from one side of the battery to a buzzer, from the buzzer to the light, and from the light to the surgical sites, one after another.



6. At the surgical sites you will need to strip the wire. Add a second bare wire in parallel to the first so that each hole has a loop of bare wire just inside the hole. Start with the site nearest the light and tape each loop in place. At the last loop, cut the wire off. This will be the end of the circuit.



7. To complete the circuit and make the buzzer buzz, you will need to attach another wire to the other side of the battery. Strip the end of this wire and stick it to the metal tweezers with sticky tape.
8. Test your circuit. The light should light up and the buzzer should buzz if you touch any of the exposed wires around your surgical sites with the tweezers.

### Finishing touches

9. Make a place to store each of the organs. Cut a strip of paper and make a curve, sticking it to the underside of each surgical site.

## Session 4

Once you have made your game, all that remains is for you to try it out. Who will make the best surgeon?

**Three sessions.** More able pupils in year 9 should understand the theories behind the experiments. For younger students the experiments demonstrate some physics principles that they can take with them to Key Stage 4.

**Who says you need to stay up all night to do astronomy?**

### Before you begin...



This activity involves making observations of the Sun. It is important that students are told that they should **never look directly at the Sun**, because this can cause **permanent blindness**. They should also definitely not use sunglasses, cameras, binoculars or a telescope to look directly at the Sun – the light will burn their retinas.

In the following few sessions the students will be able to make observations of the Sun and be able to measure how long it takes for light to travel from the Sun to the Earth.

## Session 1

The Sun might just look like a bright blob in the sky, but there is a surprisingly large amount going on if we could just see it. We can never look directly at the Sun, but to see what is going on we can build certain devices that reduce the brightness and the danger to our eyesight.

The first and most commonly used device is a pinhole camera. This is very easy to make but the image you get of the Sun is usually very small. See [www.scienceprojectideas.co.uk/tracking-sunspots-across-sun.html](http://www.scienceprojectideas.co.uk/tracking-sunspots-across-sun.html) if you would like to have a go.

Although the pinhole camera gives a nice, low-tech view of the Sun, if you use a pair of binoculars you can project a good image of the Sun onto a screen. This should be big enough and bright enough to see sunspots. Full instructions are given on the students' sheet.

Once they have made their observations of the Sun, there are many resources on the web that will help to explain what they've seen.

## Eclipses

To find out when the next partial solar eclipse is, visit the NASA eclipse website (<http://eclipse.gsfc.nasa.gov/eclipse.html>).

Use the JavaScript solar (or lunar) eclipse predictor to work out when a partial solar or lunar eclipse will be visible from where you live. Although total solar eclipses happen every couple of years, they are rare in the UK, and may have to wait several years even to see a partial eclipse.

## Sunspots

If your students manage to get a big, bright image of the Sun using the binoculars, they may see some sunspots. Have a look at the Solar and Heliospheric Observatory images of the Sun (<http://sohowww.nascom.nasa.gov>) and compare them with drawings of what your club saw.

Sunspots occur in the top-most layers of the Sun, where magnetic fields cause clumps of gas to be considerably cooler than the surrounding gas – and cooler means darker. The new solar cycle started in mid-2008 when the number of sunspots was at a minimum. As the cycle progresses over its usual 11 years, the Sun will become more active with more sunspots and more eruptions from the Sun's surface, throwing hot gas into space.

For more information about sunspots, have a look at the National Maritime Museum website and search for "sunspots" ([www.nmm.ac.uk](http://www.nmm.ac.uk)).

# DAYTIME ASTRONOMY

# 05



**Auroras: what the Sun does at night**

Although auroras aren't visible when observing the Sun, there are loads of resources about them on the web. The Sun doesn't just emit light – massive amounts of energetically charged particles are blasted off from it every second. The more sunspots that are visible, the more material that is being blasted into space. Some of these charged particles collide with the Earth and it takes around two days for them to get here. Instead of just filtering down into the Earth's atmosphere, these particles spiral around the Earth's magnetic field and give off light (accelerating charged particles emit light). The light creates beautiful patterns in the night sky, most frequently visible over the Arctic and Antarctic, but sometimes at much lower latitudes.

For more information about auroras, see the National Maritime Museum website ([www.nmm.ac.uk](http://www.nmm.ac.uk)).

For the prediction of auroras and sunspots, visit [www.spaceweather.com](http://www.spaceweather.com).

You can also find videos of the effects on video sharing sites such as YouTube ([www.youtube.com](http://www.youtube.com)).

For more projects, information and activities related to the Sun, visit the Suntrek website ([www.suntrek.org](http://www.suntrek.org)).

## Session 2

**Light doesn't travel instantly from place to place – it takes time. It may be very fast, but it still takes more than 8 min for light to travel from the Sun to the Earth. How do you measure something that fast? Well, you can do it indirectly using the frequency and wavelength of microwaves. You will need a microwave oven and lots of chocolate.**

**This works best as a demonstration, with the students doing the hard work of calculating the speed of light. If they get it right they can eat the unmelted chocolate. If your students are unwilling to do the maths, you can separate off the maths section on the students' sheet. You may or may not decide to give them the chocolate, however.**

**Microwaves are part of the same spectrum as light waves, so instead of using light we can use microwaves to calculate the speed of light.**

### What to do:

1. Take a large, flat plate and sprinkle the chocolate over it. It is best if you can cover the plate evenly and completely.
2. If your microwave has a turntable, take it out and turn it upside down so that it stops rotating. Check that your microwave will still work like this.
3. Put your plate of chocolate in the microwave and turn the power on: on full power it will take about 30 s. Keep an eye on it to make sure that the chocolate isn't overcooking, and don't let too much chocolate melt or you won't be able to measure the distance accurately.
4. Take the plate out and look at the uneven patches of melted chocolate. Some of it should still be solid while evenly spaced patches are melted.
5. Measure the distance between the melted patches of chocolate. Take care with microwave melted chocolate because it can be extremely hot.
6. Use the formulae on the next page to work out the speed of light, then work out exactly how long it takes light to reach us from the Sun.

### You will need:

- several packets of chocolate buttons, chocolate drops or Milky Bar stars for a celestial feel
- a microwave oven, either without a turntable or with a turntable that can be disabled or removed
- a microwave-safe plate
- a ruler

# DAYTIME ASTRONOMY

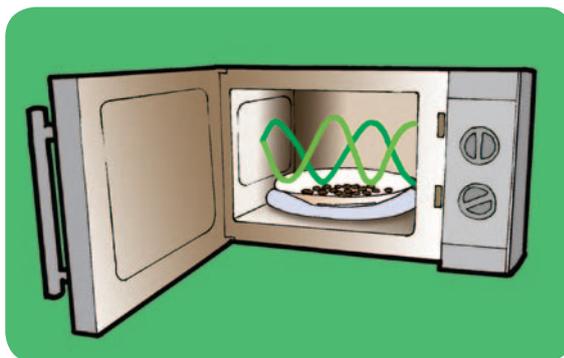
## How to measure the speed of light in a microwave

A microwave oven generates microwaves (radio waves with a frequency of around 2.45 GHz), which bounce around inside the box containing the food. As the microwaves pass through the food, they are absorbed by the water, fat and sugar molecules, which become excited and jiggle about. Atomic motion is heat, and, since the microwaves can penetrate throughout the food immediately, the heating of it is quick and even.

The microwaves reflect off the inside of the oven and bounce back towards the source. At certain points the peak of one wave coming out of the generator meets the trough of a reflected wave and they cancel each other out. If your chocolate is at this point it won't melt. In other places the peak of one wave meets the peak of the reflected wave, so the chocolate at this point begins to melt. The same is true when a trough of the emitted wave meets a trough of the reflected wave.

You can find animations of the formation of a standing wave on the web.

The points where the chocolate melts tell us about the wavelength of the wave – this is the distance between the peaks of two waves, or the troughs of two waves. The standing wave is at a maximum at both the peak and the trough of the moving waves, so the distance between the melted chocolate patches is exactly half a wavelength.



## Calculating the speed of light

The frequency of the radiation in the microwave should be labelled on the back of the microwave (usually around 2.45 GHz, or 2 450 000 000 Hz). You should find that the distance between the melted patches of chocolate is around 6 cm, giving the waves a wavelength of 12 cm (0.12 m).

For waves, we know that...

$$\text{speed} = \text{wavelength} \times \text{frequency}$$

$$\text{speed} = 0.12 \times 2\,450\,000\,000$$

Using the numbers above, we arrive at a speed of 294 000 000 m/s, which is pretty much the speed of light.

If your club got the right speed for light, and even if they didn't, they can go on to work out how long it would take for light to reach the Earth from the Sun.

They will need to use the following formula:

$$\text{time} = \text{distance}/\text{speed}$$

If everything is in metres and seconds, we have...

$$\text{speed of light} = 300\,000\,000 \text{ m/s}$$

distance between the Sun and the Earth is 149 000 000 000 m  
giving a time of 496 s, which is 8 min 16 s.

## Session 3

By now the club should be amazed at the amount of astronomy that can go on during the day. They should also have picked up an enormous number of facts about the Sun and how it can influence the Earth.

Have a look at the Institute of Physics' "Know how now" and "Food physics" public campaigns to see how amazing facts can be made into colourful and eye catching designs ([www.physics.org/facts](http://www.physics.org/facts), [www.physics.org/food-physics](http://www.physics.org/food-physics)).

Individually or in teams, the students can continue looking into different aspects of the Sun and astronomy. Can they produce a short and snappy design about a single fascinating fact? They could use their designs to produce a poster, a badge, a postcard or even a t-shirt. Don't forget: they will need to include an eye-catching image and they may need to know some background information in case someone wants to find out more.



### Some more websites that they may like to use to produce their final poster:

Curious About Astronomy? (<http://curious.astro.cornell.edu/sun.php>)

How Stuff Works, the Sun ([www.howstuffworks.com/sun.htm](http://www.howstuffworks.com/sun.htm))

ESA Kids – Our Universe, including full instructions to build a model of SOHO ([www.esa.int/esaKIDSen/TheSun.html](http://www.esa.int/esaKIDSen/TheSun.html))



### and beyond...

If students want to go further and do some early night-time astronomy, they can join Moonwatch. Visit the website to find out how to spot a new crescent moon, with help for students on how to make and report on their observations ([www.crescentmoonwatch.org](http://www.crescentmoonwatch.org)).

You can study the night sky using a real telescope without leaving the classroom. Have a look at the resources available on the Faulkes Telescope Project ([www.faulkes-telescope.com](http://www.faulkes-telescope.com)) and National Schools' Observatory websites ([www.schoolsobservatory.org.uk](http://www.schoolsobservatory.org.uk)).

# DAYTIME ASTRONOMY

## ACTIVITY 05

The Sun is our main energy source. It keeps the Earth warm and bathes us in light, which drives photosynthesis in plants. The Sun isn't just a smooth round ball of gas – it is constantly exploding material into space, releasing the energy formed in the intense pressure of its core.

### Session 1

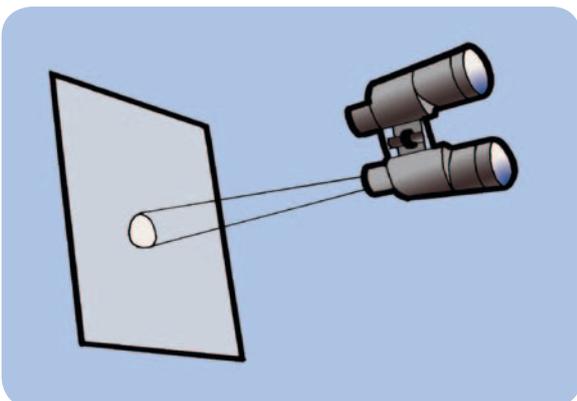


**WARNING** Never look directly at the Sun – it can cause permanent blindness. Do not use a camera, binoculars or a telescope to look at the Sun either as these will cause permanent damage to the retina at the back of your eye.

To make observations of the Sun we need to use binoculars to project an image of it onto a flat surface. **Do not look through binoculars at the Sun.**

You will need:

- a large piece of paper
- a pencil
- binoculars, preferably with a tripod



### What to do:

1. If you don't have a tripod, the best way to keep the binoculars steady is to use your shoulder. Cover one of the binoculars' lenses.
2. Hold the binoculars on your shoulder with your back to the Sun and with the wide end of the binoculars towards the Sun. The eyepiece of the binoculars should point towards a paper screen, which is taped in place on a wall, or on the floor if the Sun is high overhead.
3. Move the binoculars towards or away from the screen until you get a large image of the Sun. Then change the focus of the binoculars until the image is very sharp.
4. It is difficult to hold the binoculars steady, but do your best and get your friend to draw round the image of the Sun. Look carefully for any dark spots and mark these on the drawing – you may have found your first sunspots.

# DAYTIME ASTRONOMY

## ACTIVITY 05

### Session 2

The light that leaves the Sun doesn't immediately appear on the Earth – it takes time for it to reach us. If the Sun disappeared in a puff of smoke, how long would it be before we found out that all life on Earth was doomed? All you will need to work this out are a few facts, a microwave oven and some chocolate.

Microwaves are part of the same spectrum as light waves, so instead of using light waves to calculate the speed of light, we can use microwaves produced by a microwave oven. If your club leader has demonstrated the microwave experiment then you should know the distance between the melted patches of chocolate.

Use the following formula to work out how fast light travels from one place to another:

$$\text{speed of light} = \text{wavelength of microwaves} \times \text{frequency of microwaves}$$

The wavelength of the microwaves is twice the distance between the patches of melted chocolate (don't forget that it needs to be in metres). The frequency of the microwaves in a microwave oven is 2 450 000 000 Hz.

Have you worked out the speed of light?  
You should have a value in metres per second.

To work out how long it will take light from the Sun to reach the Earth you will need the following formula.

$$\text{time taken} = \text{distance travelled} / \text{speed of light}$$

You have just worked out the speed of light. The distance between the Sun and the Earth is 149 000 000 000 m. How long does it take for light to reach us?

The Sun is so far away that it takes a surprisingly long time for light to reach us, but not so long that we would be able to do very much if the Sun did just pop out of existence.



## Teacher notes

# PLAYING WITH YOUR FOOD

## ACTIVITY

# 06

Three sessions suitable for all ages.

In this activity the students will be looking at experiments with different foods. Despite first appearances, most food is made of mixtures of solids and liquids. Students will have a close look at jelly and try to work out what they can do to it to make it as strong and tall as possible.

### Before you begin...

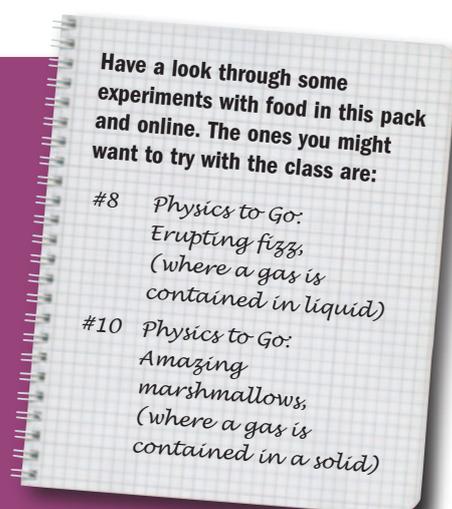
The idea for this activity comes from the Institute of Food Research's Tallest Jelly Competition. Visit its website for fantastic videos and photos of the most recent competition ([www.ifr.ac.uk/jellyvision](http://www.ifr.ac.uk/jellyvision)).

You may also like to look at "Slime" on Planet SciCast made from cornflour and water ([www.planet-scicast.com/films.cfm](http://www.planet-scicast.com/films.cfm)).

For even more experiments involving food, have a look at Planet Science's Little Book of Experiments (<http://archive.planet-science.com/sciteach/index.html?page=/experiment/>).

Select "Parents" and you'll find the Fascinating Food section.

Unless you are doing a lot of food experiments, or get very distracted by the fantastic slime, you may want to jump straight in with some jelly in the first session. You will need to make a few in advance in several disposable drinking cups. Use different amounts of jelly mixture in each to vary the amount of gelatine in each set jelly.



### Session 1

You can start by doing a few short experiments that involve food, either as demonstrations or in small groups. Remember that experiments involving food are generally messy, so make sure you have plenty of volunteers to get their hands into it. The experiments should make it clear that, despite first appearances, food is rarely made up of just one phase of matter.

Now have a look at one of your jellies that you have prepared in advance – one made up to the strength that the packet recommends. Most students might guess that the jelly is entirely a solid. However, the gelatine protein strands in a jelly are not very ordered, unlike the molecules in

a "normal" solid, leaving gaps that are filled with water molecules. This is what makes the jelly wobbly.

For more information about what jelly is made of, visit the How Stuff Works website ([www.howstuffworks.com/question557](http://www.howstuffworks.com/question557)).

The tangled proteins with tiny pockets of liquid water make it extremely difficult to build a tall, structurally sound jelly. In this activity, students are challenged to tame the wobbliness of a jelly.

There are number of things to do to help to build a strong, tall jelly. The first is to add more gelatine. If you have made up jellies at strengths that are different from the manufacturer's instructions you will notice that the ones with more

jelly mixture in them are stronger and less wobbly. In these cases there are simply more tangled-up gelatine proteins to hold the jelly together. The weaker solutions possibly might not even have set because there wasn't enough gelatine to contain the water molecules.



## Teacher notes

# PLAYING WITH YOUR FOOD

## ACTIVITY

# 06

The students can work in teams or individually to start putting together ideas for how to construct a strong jelly. The Institute of Food Research has set out some rules, which you could adapt for your club:

1. Each team is limited to a certain number of packets of jelly, making either a small quantity of very strong jelly or a large quantity of weaker jellies. Entrants in the Tallest Jelly Competition were limited to four packets of jelly, and they could only be made four times as strong as the packets recommended.
2. Only food can be used to strengthen the structure – no pouring in concrete with the mixture. According to the Institute of Food Research's rules, you must be prepared to eat any part of the jelly.

3. The base of the jelly can't be bigger than A3.

4. The jelly has to stand up on its own – no holding it up with spaghetti scaffolding around the outside.

For inspiration, the club can watch the video of the Tallest Jelly Competition or have a look at the images of scientists from the Institute of Food Research having a go ([www.ifr.ac.uk/jellyvision](http://www.ifr.ac.uk/jellyvision)).

By the end of this session, each team will need to have some ideas about what moulds they would like to use (one tall one and lots of little ones?) and they may want to make some jelly up in small cups so that it will be set for the next session. They will need to bring their moulds into session 2.

### Sessions 2 and 3

If the students have already made up some jelly and no one has eaten it between sessions, they will want to get stuck straight into trying to balance their jellies. If the teams want to experiment with adding different food to their jellies or try out different moulds then this may take another session because they will have to wait for them to set.

At the end of these sessions the students will need to have made up their final design and put it in the fridge to set.

### Final session

Now is the time to start putting it all together. For those with just one large mould, this might just mean tipping it out, but some will have to construct their tall jellies from numerous small ones. This can be quite time consuming. For fairness you should set a time during which the jelly must stay upright, otherwise pupils judged last will have to have their jellies stand the longest. Make sure you leave enough time at the end for judging and awarding prizes. You can have an overall winner for the tallest jelly, a prize for ingenuity and a prize for the most artistic creation.

### ...and beyond

If you have enjoyed this activity and you are part of a school in Norfolk, Suffolk, Cambridgeshire or Lincolnshire you can enter the annual Institute of Food Research's Tallest Jelly Competition ([www.ifr.ac.uk/jellyvision](http://www.ifr.ac.uk/jellyvision)).



# PLAYING WITH YOUR FOOD

## ACTIVITY 06

Food is rarely just a solid or a liquid: it's the gas in fizzy drinks that make them tingle, the air in marshmallows that make them squidgy and the water in apples that makes them juicy.

In this activity you will be taking a jelly – a mixture of solid gelatine and water – and making it considerably stronger. The objective is to build the tallest jelly in the world, or at least taller than anyone else's in your club.

### The rules

1. Each team can only use a certain number of packets of jelly, so you can make a small, strong jelly or a weak, big jelly.
2. Only food can be used to strengthen the structure – no pouring in concrete with the mixture. You must be prepared to eat any part of the jelly.
3. The jelly has to stand up on its own – no holding it up with spaghetti scaffolding.

It may sound simple, but making a tall jelly is astoundingly difficult.

Start by looking at the difference between using a lot of jelly mixture (less water) in your jelly to make a more concentrated jelly and using less jelly mixture (more water) to make a less concentrated jelly.



### Which do you think you might use in your final jelly?

What kinds of material are used to hold buildings up? Where are these materials found in the building and what is special about them that allows skyscrapers to stay standing? What food materials look similar to those used in buildings?

Jelly has a lot of water in it. What effect will this water have on the materials that you are hoping to use to give your jelly more strength? Are there any foods that won't be affected by the water?

Why do tall things fall down? Stand up straight and lean forward. At what point do you feel yourself tipping forward? How do you prevent yourself from falling? Does this influence the shape of your jelly?

If you push your finger into a jelly, does it go in easily? What if you push down with your entire hand? What kind of force does the very base of a tall jelly feel, and what happens if that force is too great? Is there a way to reduce this force?

Experiment with lots of different food.

## Teacher notes

**BUILD YOUR OWN EGGPOD**

Three or more sessions, suitable for years 5 to 9.

If you drop an egg on the kitchen floor it is sure to break. Can your club manage to drop eggs from the top of a building without them breaking? Don't forget to involve students and teachers from design and technology to see what great eggpods they can produce to protect their eggs. Make it into a competition between individuals or teams.

**Before you begin...**

Pick out some short experiments that explore how and when eggs are strong and where they are at their weakest. Take a look at the list on the right for some examples.

You could also look at videos of egg challenges on video sharing sites such as YouTube. You can search for "Egg Drop" to see examples of previous challenges, or find out what would happen if an egg didn't wear its seat belt by searching "Eggs seat belt".

If you want to go a step further with the egg drop, you can film the design, construction and potential destruction of your eggpods.

**In this pack you will find:**

- #4 Marvin and Milo: Spinning the eggs
- #17 Physics to Go: Egg-citing physics
- #18 Physics to Go: One in the hand
- #40 Marvin and Milo: Daredevil egg

**Session 1**

Students can work individually or in pairs. Let them have a go at some of the short experiments in this pack. "One in the hand" is particularly useful. They can even try standing on a pack of eggs.

You will need:

- a box of 12 eggs
- a reasonably small volunteer
- a table or chair to support some of their weight
- an outside space, plastic sheet or floor you don't mind having raw egg on.

**What to do:**

1. Make sure all of the eggs in the box are the same size, with the bottom of each egg facing down. You may want to put a hardback book or something similar on top of the lid to ensure that the weight is spread evenly.
2. Place the box of eggs and the chair next to each other on the floor.
3. Ask a volunteer to support their weight on the chair and step gently onto the box of eggs. Tell them to keep most of their weight on the chair until both of their feet are on the box.
4. Ask them to release themselves slowly from the chair and, without a crack or a crumple, they are standing on 12 eggs.

## Teacher notes

# BUILD YOUR OWN EGGPOD

## ACTIVITY

# 07

**Now explain the egg stunt challenge. You will be throwing or dropping an egg in a way that is sure to make it smash into pieces if it isn't protected. You may decide to drop the egg or try throwing it over a certain distance. Each impact will be different and may require different**



Can the students use the strength of eggs to help their “egg-stronaut” survive the challenge? Let them set about planning ways to protect their egg in their very own eggpod, if there is time in this session.

There are very few rules to this, but you can always add a few to make it trickier. Try the following:

1. Students can only use paper to protect the egg.
2. The egg must be visible – brilliant if they decorate it like an astronaut.
3. Students must be able to construct their design in less than 5 min.
4. The weight limit of the eggpod (without the egg) is 500 g.

5. Students can construct a suitable base to soften the impact.

6. The eggpod must be made with more than five different types of material.

If you are planning to make this into a competition, you could also add a few judging criteria:

1. The winner will be the person with the lightest eggpod.
2. The eggpod must land in a designated area.
3. Extra points are awarded for the most attractive eggpod.

## Session 2

The students can start testing some of their eggpod designs at low heights: no standing on chairs or tables. Save the full stunt egg challenge until the competition is being judged. They can then take a look at some of the videos online of other people's attempts to protect their eggs and make adjustments to their own inventions.

To allow enough time in the final session, some students with very complex eggpods may need to start making the final design towards the end of this session.

## Session 3

To make sure you have enough time in this session to try everyone's designs, you will need to set a time limit on making the eggpods. Each student or team will need three eggpods because they will drop or throw their eggs three times to test their design properly.



### WARNING

Some of the designs may be heavy and falling from a height. Make sure that no one is in a position where they could be hit by an eggpod. Make sure that students drop their eggs from somewhere where they do not have to lean over. You will need at least one person with the students at the top of the drop and someone else monitoring the fall at the bottom.

You can set your own criteria for the winner if more than one egg survives the fall – or if none survives (e.g. ingenuity of design or best decorated egg-stronaut).

## ...and beyond

If your club has mastered the art of protecting the egg from considerable forces, perhaps it needs more of a challenge? Egg challenges can be found nationally and locally.

The Young Engineers have a yearly challenge called Project Eggs Factor ([www.youngeng.org](http://www.youngeng.org)).

There are a number of local egg races during National Science and Engineering Week. To find out what is going on in your area, visit [www.britishecienceassociation.org/national-science-engineering-week](http://www.britishecienceassociation.org/national-science-engineering-week).

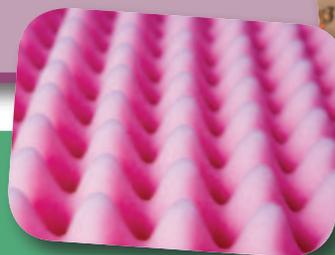
Student worksheet

# BUILD YOUR OWN EGGPOD

ACTIVITY

# 07

Eggs are surprisingly tough, but are they tough enough to survive a fall of a couple of storeys onto concrete? We don't think so – at least not without a little help...



## Session 1

Start with one egg and think about ways in which you might protect it from a perilous fall.

Which parts of an egg are strongest?

What kind of impact is most likely to end up with an egg disaster?

In experiments where the egg doesn't break, what kind of force did the egg feel and where was this force on the egg?

What is it about the shape of the egg that makes it strong? Where have humans copied this shape to make equally strong structures?

What kind of objects are designed to deal with impacts all of the time and how are they designed to protect their contents? Do they use just one method or several?

Where in physics might you find very delicate equipment dropped from tremendous heights? What do scientists use to protect the equipment?

Start working on designs for your eggpod. Don't just stick to one – try several until you perfect the design enough to save egg after egg.

## Session 2

Start making up your designs and trying out your eggpods for eggs dropped from reasonably low heights – try at arm's length from above your head to begin with.

If you are finding that your eggs are constantly smashing, you need to rethink your designs.

## Session 3

Make up your final eggpod design. If it isn't reusable you may need to make as many as three of them for the competition.

Take your egg-stronauts and your eggpods to the testing site and see if all of your work has paid off.

# PHYSICS OF CARTOONS

Two sessions suitable for year 7 to year 9.

Who would have thought that watching cartoons could help with physics? You can spend one or two sessions watching cartoons and get the students to spot where the laws of physics have or haven't been abandoned.

## Before you begin...

You will need to find a selection of cartoons. You can look on sites such as YouTube ([www.youtube.com](http://www.youtube.com)) for some useful ones, or use an episode of **The Simpsons** or any other cartoon that your club chooses. If you can find an episode of **Roadrunner** you'll have a wealth of classic physics impossibilities to work with.

An alternative to cartoons is clips from any number of films that choose to ignore the laws of physics. Generally there are three types of film to spot bad physics in:

- films with gadgets – **Bond** films are the best;
- those with a science theme – although there is a lot of truth in these, they often embellish the physics to make it a bit more eye-catching (e.g. **The Day After Tomorrow** and the **Indiana Jones** films);
- films with superheroes almost never obey the laws of physics;

For helpful hints on bad physics in films, have a look at **Bad Astronomy** ([www.badastronomy.com/bad/movies](http://www.badastronomy.com/bad/movies)) and this **Physics World** article: <http://physicsworld.com/cws/article/print/25251>.

Here are some examples:

*Road Runner* "Soup or sonic"

*The Simpsons* "Space chips"

*Scooby Doo* "Watt a shocking ghost"

You can also have a look at the Cartoon Network, Nickelodeon and Disney websites. Select "videos" to watch some of the cartoons and trailers.

## Session 1

Divide the club into four teams if you have more than eight people or into two teams if you don't. Decide who is spotting the physics and who is spotting the antiphysics, with teams doing one or the other. Watch the cartoon. Each team spotting the physics needs to note when real physics is shown, while those spotting the antiphysics should note when the laws of physics have been broken.

### Real physics

Commonly, these laws of physics remain intact in cartoons:

- gravity (to a certain extent)
- friction

- forces
- parabolic motion

### Antiphysics

These laws, however, are often abandoned for the sake of comedy:

- gravity (the effect is usually delayed)
- conservation of mass
- magnetism
- electricity

Once everyone has enjoyed the cartoon, compare results. Which team(s) found the most examples of real physics? Combine the results and compare them with the team(s) looking for examples of antiphysics.

Did you find that the characters were more or less likely to obey the laws of physics?

## Session 2 and beyond

Want to make your own cartoon? Why not try filming an animation? You could try making the same one twice, first using the correct physics and then throwing the physics out of the window. Which one is more dramatic? Why not enter SciCast Physics? For all of the information that you need to make your own animation – from necessary equipment to what music to add – have a look at the SciCast website ([www.planet-scicast.com/films.cfm](http://www.planet-scicast.com/films.cfm)).

Student worksheet

# PHYSICS OF CARTOONS

## ACTIVITY 08

Have you ever wished you could do some of the things that you see in cartoons? Well, you can't, because cartoon characters are not governed by the same laws of physics that we are. By ignoring physics they can jump off cliffs, crash and explode, and never suffer the consequences.

### Did you know?

Just to walk along the street you rely on friction to propel yourself forward and gravity to keep you on the ground. Electromagnetism prevents you from sliding through the Earth. You will also feel some air resistance – lots if it is a windy day – and just the right amount of air pressure to prevent you from exploding or imploding.

**But what fun would it be if cartoon characters never broke the rules?**

**Here are some examples of where cartoon characters don't behave as you might expect. Work in your teams to spot when they obey the laws of physics and when they don't.**

### Gravity

Everyone and everything on the Earth needs the force of gravity. Without it we'd float off into space, and so would all of the air that we need to breathe. We are constantly being pulled towards the centre of the Earth by gravity. In an aeroplane the amount of lift from the wings equals the force of gravity, so the plane doesn't plummet from the sky but gravity is still there.



# PHYSICS OF CARTOONS

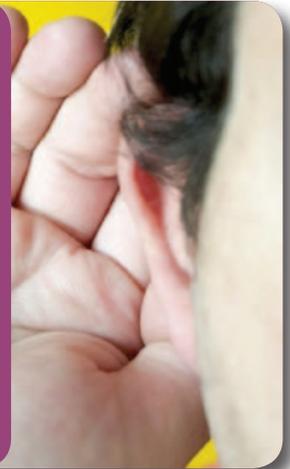
## ACTIVITY 08

### Conservation of mass

Things can't get bigger or smaller at will – material has to be added from somewhere, or taken away. For example, if something inflates, this means that air (or another gas) is added to it. The only exception would be something inflating in space, which would be due to the pressure inside it being greater than the pressure in space. Watch out for things changing size depending on what conveniently fits on the screen.

### Sound

Sound needs something to travel through. So, if someone tries to pretend that we can hear sound in space, don't believe them. You'll also have to be pretty careful about working out how far sound is likely to travel.



### Friction

All cartoon characters walk around at some time. To do this they need friction. They also need friction if they do a sliding stop or ride a bike. Friction in its other form – air resistance – will be involved if someone uses a parachute or flies a kite, and if there is any wind. A lot of the time animators are only too happy to use friction, but did they use too much or too little? Did it strangely disappear at the very beginning of a high-speed chase?

### Distances

The Sun is our nearest star. With current technologies it would take us a long time to get there. The Space Shuttle travels at 28 000 km/h, so it would take about 220 days to reach the Sun travelling straight there. The next closest star is just over four light-years away, so it takes four years for the light to get from the star to us. If your cartoon suggests that now, or in the near future, we will be popping off to another star, make sure you make a note.

### Electricity

Generally if someone gets an electric shock they will be badly burned. You wouldn't expect them to walk away from it.

**If you keep your eyes open you will find lots of other instances where the laws of physics have been exaggerated to make a cartoon funnier or a film more dramatic. You don't even need to know the name of the physics involved – just ask yourself: “Is that possible?”**

Teacher notes

# SEASONAL SCIENCE

ACTIVITY

# 09

Suitable for all ages and can take as many sessions as you like, from filling up one session with something seasonal to researching a whole theme and putting on a science show.

## Filling a single session

If you just have a single afternoon to fill at the end of term, you may want something more topical to entertain the club. You can do some activities that are related to the time of year, or a calendar event.

If you want a theme to build a science show around, you'll find below a list of ideas and experiments. Decide on a date for the show and use the calendars to help your students to come up with a theme.

For Brain Awareness Week, usually held in March, you may want to do some experiments that use even more brain power than normal.

The following Marvin and Milo experiments may look simple but the physics is complex:

- #36 Marvin and Milo: On a roll
- #39 Marvin and Milo: Loop the loop
- #42 Marvin and Milo: Antigravity Maltasers

National Smile Month usually happens in June.

You may choose to do experiments that are particularly funny, such as:

- #8 Physics to Go: Erupting fizz
- #12 Physics to Go: Balloon kebabs
- #9 Marvin and Milo: Alka-Seltzer rocket
- #25 Marvin and Milo: Indestructible bag

If you want to stay dry, stick to these Marvin and Milo experiments:

- #12 Foil boat
- #17 Reversing glass
- #20 Melting race
- #21 Simple siphon

If you find yourself with a very wet day, why not use water as your theme? You can do the following Marvin and Milo experiments as demonstrations or set them up so that everyone in the club can have a go.

However, if you are prepared to get out a few towels, try these Marvin and Milo experiments:

- #1 Straw water gun
- #18 Juice carton sprinkler
- #23 Stringy water
- #24 Water jets



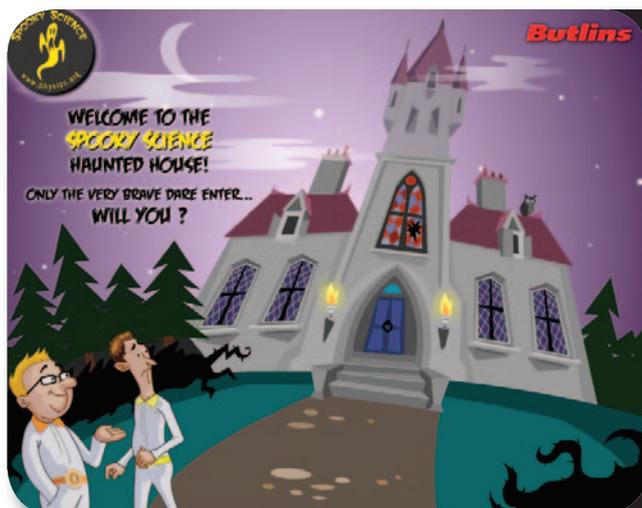
## Teacher notes

SEASONAL  
SCIENCE

Left-Hander's Day is usually in August. Do you know how difficult it is being a left-handed person living in a right-handed world? How about trying some tricky (but safe) experiments using mainly your left hand if you are right-handed, or your right hand if you are left-handed, then switch and see how bizarrely asymmetrical the human body is.

You could try the following Marvin and Milo experiments:

- #37 Clumsy catching
- #39 Loop the loop
- #40 Daredevil egg



Science activities in October could involve Halloween. Take a look at the Institute of Physics Spooky Science webpages ([www.physics.org/spooky-science](http://www.physics.org/spooky-science)) for facts and experiments to keep you amused and slightly freaked out.

## Putting on an end-of-term science show

Two big reasons for having a science show are to raise the profile of the club and to charge entry – not only to pay for any equipment you need for the show but also to raise funds for future projects.

You can team up with the drama department and use their talent to help with the design, costumes and general theatrics. After all of the work you might also want to show off what you do to primary students who will be joining your school (and obviously the club) the following year.



## Decide on the type of show

Your show can take many different forms, from a series of science demonstrations to a scripted performance with the science experiments slipped in here and there. When deciding, you might want to have some science demonstrations in mind, but don't finalise the list just yet.

Groups of students could put together a series of short experiments or science magic tricks. In pairs, they might put together 5 min demonstrations. For activities that are small or require audience participation, you could divide the audience into groups, moving from one demonstration to the next.

Have a look at the information on putting together a science fair in the first section of the pack to get some general ideas of what might be needed to run a large event.

## Look at the audience, venue and length of performance

Whichever type of show you choose, you'll need to look at the venue and the size of the audience, and work out what experiments are likely to be visible to everyone – there's no point in doing a fascinating but tiny experiment that only the performers can see. You will also need to know how long the show will last so that you don't over- or under-run.

## Think of the running order

If you are going to do a series of demonstrations around a theme, you should try to start and finish with something fairly big, with more thought-provoking experiments in between.

If you are working with small groups, the short series of experiments should be linked with a theme.

## Work out your script

If you want to produce a fictional story, you will need to come up with the genre: romance, murder mystery, biographical, even a musical. Rather than putting the experiments into the script, start with the experiments you'd like to perform and that are suited to that type of show, and then build up a story to link them together. A story involving science might be the most obvious, but science can pop up in the most unusual places. How about a story of a haunted house, with convection snakes, a van de Graaff generator, any experiments involving moving objects from a distance and, of course, creepy lighting.



## Get the audience involved

Another thing to keep in mind is how to keep your audience gripped. A good script will do this, or a well planned running order for the demonstrations. However, even better is getting the audience to be part of the science. If the demonstration involves someone getting messy or wet, put a stooge in the audience – as far as the audience is concerned, this could be any one of them getting soaked.

Even if you don't need someone from the audience helping with the demonstration, ask them questions about what they expect to happen, how the demonstration worked or what other materials could be used in the demonstration. This works particularly well if you are working in small groups. The more your audience does for themselves, the more they will enjoy it.

Teacher notes

# SEASONAL SCIENCE

ACTIVITY

# 09



## Remember safety

Consider how safe the experiments are. Rockets and flying things are always spectacular, but they will have to come down somewhere, so keep this in mind if you are going to use them. If some of the experiments are a little too dangerous for audience members to repeat on their own, make sure you don't give away too many instructions and let the audience know not to repeat them. Get them to join your club instead.

## Don't forget the people behind the scenes

You'll need plenty of people to help with the show, from costumes and lighting, to setting up the experiments.

## Making it last

Film your show, from the first ideas stages to the final performance. You can use some editing software to piece it all together.



# FURTHER IDEAS

Further ideas for STEM club activities are listed on the following pages. If you are new to running a club, you should also go to the STEM Clubs website ([www.stemclubs.net](http://www.stemclubs.net)) for additional information.

## Run a book group

Book groups generally run once a month or every couple of months, giving people enough time to read the book that they are going to discuss. You could run a book group in addition to the other activities in your club, dedicating one session every half-term to discussing the book that you decided on in the last book group meeting.

## Big Bang Books

[www.physics.org/bigbangbooks](http://www.physics.org/bigbangbooks)

The Institute of Physics has a list of books that give a glimpse of life behind the experiments: the kind of physics that you won't find in textbooks. Have a look at the reading guide to see which are suitable for the students in your club. You'll find experiments to perform that complement the material in the books, fascinating physics facts and ideas to debate.

Once you have read the recommended books, why not ask students for their suggestions? Write reviews and debate whether the science in the science-fiction books would ever be possible. Don't forget to e-mail your reviews to the Institute.

## Sign up for I'm a Scientist, Get me out of here

[www.imascientist.org.uk](http://www.imascientist.org.uk)

I'm a Scientist is a free online X-Factor style competition for scientists, where students are the judges. Your students read the scientists' profiles, ask them questions and have live online (text) chats with them. Students vote for their favourite scientist to win £500 to spend on science communication.

*"I'd ask a question, and they'd give me an answer, and then I'd have loads more questions, and then more"*  
Student, West Thames College

The screenshot shows the 'I'm a Scientist' website interface. At the top, there's a navigation bar with 'Home', 'Scientists', and 'Search' options. Below this, there are five scientist profiles, each with a photo, name, and a short bio. The profiles are: Tom Lister, Tim Stephens, Tianfu Yao, Philippa Bird, and Michael Bloom. Each profile includes a 'Read more about me' link. Below the profiles, there are several student questions and comments. For example, under Tom Lister, a question asks 'Why does soda pop?'. Under Tianfu Yao, a question asks 'Is there any proof other than myths and rumours that other life forms exist?'. The interface also features a 'Meet the Scientists' section at the top right and a 'Laser Zone' logo.

Students become more enthused about science, learn that science lessons relate to real life, and see that scientists are normal people.

It runs in March, June & November and is **completely free for schools**.

It's open to all secondary students,

but most commonly used by Year 9 students. All teachers are sent a Teacher Pack with lesson plans and a science debate kit, to help introduce students to the event and reduce the lesson planning required.

Register at [www.imascientist.org.uk/teachers](http://www.imascientist.org.uk/teachers)

# FURTHER IDEAS

## Play some games

You'll find loads of online games and interactive activities on [www.physics.org](http://www.physics.org). These are great to fill in gaps between longer activities, or to kick start an activity with a bit of background information.

### Sim Physics

[www.iop.org/simphysics](http://www.iop.org/simphysics)

The Institute of Physics has four interactive games – SimEnergy 1, SimEnergy 2, SimSpace and SimSound – all designed to get students to use physics to solve problems and win the game. Each comes with teachers' notes.

#### SimEnergy1

Teach a family how to save energy and use insulation to stop their house from freezing in the coldest winter on record.

#### SimEnergy2

Add renewable forms of energy to this Sim family's house. They will be microgenerating and selling their excess energy back to the electricity company, unless you are losing, in which case they will use up their carbon quota and have no more power.

Both of these games are great for introducing students to the concepts of energy saving and using renewable energy on a small scale.

### SimSpace

Can you save the Earth from a potentially lethal asteroid strike? This game is quite difficult so will keep older students working for ages. Track a potential threat, see how close it will get to the Earth, figure out what risk it poses then blow it up.

### SimSound

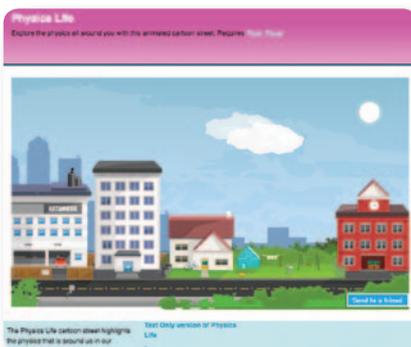
Investigate the physics of sound and music, then use your knowledge to put together your very own rock band.



### Physics Life

[www.physics.org](http://www.physics.org)

Wander down the Physics Life street and pop into peoples' houses or businesses to see what role physics plays in their everyday lives. You'll find information about some of the technology around us, such as car design and gadgets found at home and in school.



### Physics Evolution

[www.physics.org](http://www.physics.org)

This interactive map lets you look at the history and evolution of physics from 3500 BC to today. Find out how scientific breakthroughs influenced each other in different eras and in different places.



# FURTHER IDEAS

## Meet a physicist

**If you are looking for someone to bring some enthusiasm and a different perspective on physics to your club, you'll find that many physicists are happy to come and talk about what they do – you only have to find them.**

There are a number of places where you can go to find the right people and the right topic:

### The STEM Directories

[www.stemdirectories.org.uk](http://www.stemdirectories.org.uk)

The STEM Directories are a source of activities, resources and events available to schools in the UK and will be searchable online from summer 2009.

### Science and Engineering Ambassadors

[www.stemnet.org.uk](http://www.stemnet.org.uk)

Activities range from arranging visits to local industries and business to bringing SEAs to schools. Use the website to find your local STEMNET contract holder and start from there.

### Lab in a lorry

[www.labinalorry.org.uk](http://www.labinalorry.org.uk)

This mobile lab brings experiments and activities to your venue, with practising scientists sharing their enthusiasm for science with students aged 11–14. Have a look at the website to find out how to bring the lab to you.

### Royal Institution

[www.rigb.org](http://www.rigb.org)

The Royal Institution has an education outreach programme, bringing experiments, demonstrations and scientists to schools. Have a look at the website for more details of the age ranges and subject areas that it can cater for. And don't forget to look for information about the Royal Institution Christmas Lectures.

## Café Scientifique

[www.juniorcafesci.org.uk](http://www.juniorcafesci.org.uk)

[www.cafescientifique.org](http://www.cafescientifique.org)

Café Scientifique is for the general public. Go along and have a cup of coffee or a glass of wine and discuss topics in science in an informal setting. A short talk by a scientist is followed by discussion and questions, and you can join in or just relax and listen.

The same format is available for secondary schools at Junior Café Scientifique. Have a look at the website for details of how to get your club involved, and for Café Sci venues and topics.

## Science Live

[www.sciencelive.net](http://www.sciencelive.net)

Science Live is an online directory of talks, presentations and workshops delivered by professional science and engineering communicators and committed enthusiasts. Visit the website to find out how Science Live can help you to find a suitable speaker or presenter for your club.

## Hold or enter a science fair

**What better way to show off what you have been up to all year than to hold a science fair. It will allow students to demonstrate what they have learned and encourage others to join your club and get involved.**

However, holding a science fair is not just about setting up some tables with the students' work on them. A comprehensive guide is given in the ASE website under "Science Year CD ROM Primary Science" ([www.syed.co.uk/primary/enhancing-science/science-fairs.htm](http://www.syed.co.uk/primary/enhancing-science/science-fairs.htm)).

Although aimed at primary school science fairs, this easily applies to Key Stage 3 as well.

Don't forget to enlist some discerning judges and make time for the awards ceremony.

If you don't want to run a science fair yourself, why not enter a regional or national science fair? Start by looking into the British Science Association CREST fairs. Regional science fairs are organised by skill level, related to the CREST Awards. Take a look at the pages about the CREST awards and fairs ([www.britishscienceassociation.org/crest](http://www.britishscienceassociation.org/crest)).



You will also find information for younger students.

Have a look at the Big Bang UK Young Scientists and Engineers Fair ([www.thebigbangfair.co.uk](http://www.thebigbangfair.co.uk)).

This is open to all students aged 13–19. The National Science Competition ([www.nationalsciencecompetition.org](http://www.nationalsciencecompetition.org)) is part of the fair and awards prizes to the UK Young Scientist and the UK Young Technologist of the Year.

# FURTHER IDEAS

## Further information

The Institute of Physics offers an **Affiliation Scheme** for schools and colleges ([www.iop.org/affiliation](http://www.iop.org/affiliation)). Signing up to the scheme entitles you to access a range of resources that could be used in your club, such as copies of our newsletter *Classroom Physics*, with information about events and practical ideas, posters and careers material.

Students can have a look at [www.physics.org/careers](http://www.physics.org/careers) to find out where physics can take them.

**Shape the Future** ([www.shapethefuture.org.uk](http://www.shapethefuture.org.uk)) from the Royal Academy of Engineering is a campaign to raise awareness of engineering and technology as a career. Download the directory to find an enormous list of clubs, events and competitions that you can get involved in.

**Future Morph** ([www.futuremorph.org](http://www.futuremorph.org)) is a careers website that shows how a background in STEM can be invaluable in virtually any profession. Aimed mainly at students, it is fun and accessible. It also has areas for parents, teachers and careers staff.

Sign up to **Planet Science's** ([www.planet-science.com](http://www.planet-science.com)) newsletter, where you will find useful weekly information and national and regional events.

For even more short activities than you will find in the final section of this pack, here is a list of online resources:

**The Little Book of Experiments and Wired Science Magic Box** by Planet Science ([www.planet-science.com](http://www.planet-science.com)).

**SciZmic**, the Science Discovery Clubs network ([www.scizmic.net](http://www.scizmic.net)).

**Exploratorium** ([www.exploratorium.edu](http://www.exploratorium.edu)).

**Steve Spangler Science** ([www.stevespanglerscience.com/experiments](http://www.stevespanglerscience.com/experiments)).

## Contact the Institute of Physics

If you would like to find out more about any of the Institute's resources, then please contact us:

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Institute of Physics  
76 Portland Place  
London W1B 1NT

Tel +44 (0)207 470 4800 Fax +44 (0)207 470 4848 E-mail [education@iop.org](mailto:education@iop.org)



## Don't forget health and safety!

You'll have to think about health and safety with each activity. Try out activities first and work out where safety may be an issue with your club, ensuring that the activities are supervised at all times.

If you don't already have a copy of the ASE's **Be Safe** booklet, you can get one through the website ([www.ase.org.uk](http://www.ase.org.uk)).

For full health and safety information for schools, have a look at the CLEAPSS website ([www.cleapss.org.uk](http://www.cleapss.org.uk)).

You may also want to think in advance of any resultant mess and take appropriate precautions to minimise the amount of time spent cleaning up.

Some of the activities in this pack involve using food. If you are running these activities in the lab then try to make sure that no food brought into the lab is eaten.

## If in doubt, take advice!

Resources and websites provided by other organisations have not been safety checked by the Institute of Physics. As usual, it is the responsibility of the club leader in charge to ensure that any activities carried out are appropriate and conducted in a safe manner.