STEM CLUBS

NUMBER 1 FOR STEM

STEM ON SCREEN: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

STEM Learning activity resources

SUBJECT LINKS

Biology, chemistry and physics.

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STEM Learning activity resources

Introduction

This programme of activity is provided by STEM Learning, the largest provider of STEM education and careers support in the UK. It has been developed in partnership with Club leaders.

This programme is part of STEM on Screen, a set of three programmes exploring science, technology, engineering and maths in the movies.

Is there witchcraft and wizardry in the real world?

You may think that magic and spells only exist in your favourite books and movies. But can we make magic in the real world?

This programme investigates how you can use science to make things change colour and state, or even disappear.

Key information

AGE RANGE: 11-14.

SUBJECT LINKS: Biology, chemistry and physics.

DURATION: A range of activities from 20 to 60 minutes – 6 hours in total.

FLEXIBILITY: Complete the whole programme over a half term or choose individual activities to suit the needs of your club.

RESOURCES: Each activity includes a list of the resources required and a comprehensive set of club leader and student notes.

IMPACT MEASUREMENT: Each set of resources is designed to help evaluate and assess the progress of club based learning on club members. A useful set of assessment tools are available at www.stem.org.uk/stem-clubs

ACHIEVEMENT: Students that successfully complete a complete set of activities can be rewarded with the downloadable STEM Clubs Certificate of Achievement. Successfully completing a set of themed activities enables students to enter for a CREST Discovery Award. Further information is available on the STEM Clubs website.

APPROPRIATE VENUES: Club leaders can run most activities in general spaces e.g. classrooms, halls, and outdoor areas. Some activities need to be conducted in labs and workshops – these are marked clearly in the Club leader guide and in the table below.

SAFETY: Each activity includes details about significant health and safety considerations, such as appropriate eye protection, gloves, etc. Club Leaders should ensure that all equipment is handled with care, particularly sharp instruments. Advice and guidelines are available from CLEAPPS and SSERC, or see the STEM Clubs handbook (page 20). We recommend that practical activities are risk assessed before commencing and Club Leaders must follow their employer or organisations policies. Other activities: Visit www.stem.org.uk/resources/stem-clubs/ for a wealth of ideas for STEM-related Clubs.

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FURTHER SUPPORT: The STEM Clubs best practice handbook includes comprehensive support for leaders of all STEM-related clubs. It can be found at www.stem.org.uk/stem-clubs/getting-started

Activities

1	**POTIONS:** In this activity, students watch a demonstration and then trial making their own magic water bright pink with just one magic colourless drop. Students will experiment with an indicator and explore how sensitive it can be.	45 minutes	**Lab required**
2	**CARE OF MAGICAL CREATURES:** In this activity, students view a demonstration of a snake rising from fire. They will explore how incomplete combustion of glucose yields carbon.	45 minutes	**Lab required**
3	**HERBOLOGY:** In this activity, students extract limonene from an orange. Students will explore how to use distillation apparatus to isolate substances.	60 minutes	**Lab required**
4	**ALCHEMY:** In this activity, students watch as a copper coin is transformed into gold. Students will explore how to make metal alloys and see how they exhibit different properties.	60 minutes	**Lab required**
5	**INVISIBILITY CLOAKS:** In this activity, students make materials disappear by suspending them in liquids of a similar refractive index. Students will explore the idea of refractive index and how similar materials refract light in similar ways.	30 minutes	**Lab required**
6	**LEVITATION:** In this activity, students build a levitating hovercraft. Students will explore the idea of equal and opposite forces, causing an object to rise upwards.	40 minutes	**Classroom required**
7	**APPARITION:** In this activity, students build a device that will reflect an image in multiple ways, creating a hologram.	50 minutes	**Classroom required**
8	**CHARMS:** In this activity, students change the colour of flowers to one of their choice. Students will explore the biology of a plant demonstrating the position of the xylem in a plant.	30 minutes	**Lab required**
9	**GET CREST DISCOVERY AWARDS:** By completing all nine activities in this resource pack, your STEM Club members can get a CREST Discovery Award.		

STEM CLUBS

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CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

1 Potions

Objective

In this activity, students watch a demonstration and then trial making their own magic water bright pink with just one magic colourless drop. Students will experiment with an indicator and explore how sensitive it can be.

TOPIC LINKS

Chemistry: acids and bases

TIME

45 minutes

RESOURCES AND PREPARATION

- beakers (2 per group)
- water
- measuring cylinder (or burette)
- pipettes (3 per group)
- white tile
- magnetic stirrer (optional)/glass stirring rods
- solid sodium (for demonstration only: highly flammable, corrosive, 4 mm cubes)
- 0.1 M sodium hydroxide solution (irritant)
- phenolphthalein (flammable, harmful)
- tweezers
- filter paper
- scalpel or sharp knife to cut the metals
- gloves
- safety goggles
- large glass trough
- safety screens

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity.

Pupils should wear safety goggles and sit behind a safety screen.

If you have not used alkali metals before, you are strongly advised to practise first

- sodium should only be handled by the club leader
- sodium metal should be stored under liquid paraffin
- handle sample using forceps, wear eye protection and use safety screens
- conduct all demonstrations on a small scale – use rice grain-sized pieces
- make sure everyone involved (e.g. technicians clearing away) understands the hazards
- take steps to avoid theft

DELIVERY

1. Explain that potions are magical mixtures brewed in cauldrons – but we can find non-magical equivalent in the chemistry lab!
2. Fill a trough about half full with water. Add 10 drops of phenolphthalein.
3. Set up 2 safety screens so all angles from which students are viewing are protected.
4. Remove the metal from the paraffin with dry tweezers and place it onto a white tile.
5. Use the tweezers to hold the metal against the filter paper to blot off any excess oil.
6. Cut a piece of metal about the size of a grain of rice with the scalpel. You may need to cut off any tarnished metal to expose the shiny metal underneath.
7. Place any pieces you will not be using back into the oil.
8. Ensure the bottle lid is securely closed.

9. Use the tweezers to add the rice grain-sized piece of solid sodium into the trough of water with phenolphthalein.
10. Explain that adding sodium causes sodium hydroxide to be made, which turns the phenolphthalein pink as an alkaline solution has been made.
11. Explain that adding sodium hydroxide will also change the colour of the solution.
12. Set the students a challenge: can they make a clear solution, where one drop of sodium hydroxide added will cause a permanent colour change to pink? The students will need to figure out the quantities of water and sodium hydroxide to use.

DIFFERENTIATION IDEAS

Support: give all students a set volume of water to work with. Give students a clue as to how to solve the challenge. Encourage them to trial different amounts of sodium hydroxide and see how much is required to turn the solution pink. Ask students to record how much sodium hydroxide is required.

Challenge: encourage students to experiment and try things out – let them know they can wash out equipment and use it again. Support them as they solve the challenge but give no clues! Allow different groups of students to work with a volume of water of their choice.

EXTENSION IDEAS

1. Ask students whether this reaction is reversible? How?
2. Ask students to think about circumstances where monitoring pH is very important.
3. Get students to experiment with other types of indicator.

TIPS

Once students have trialled and tested to get their perfect measurements, let them show their magic in class the next day to peers who weren't in STEM Club.

If pupils are unable to see the demonstration, ample clips are available online.

STUDENT GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

1 Potions

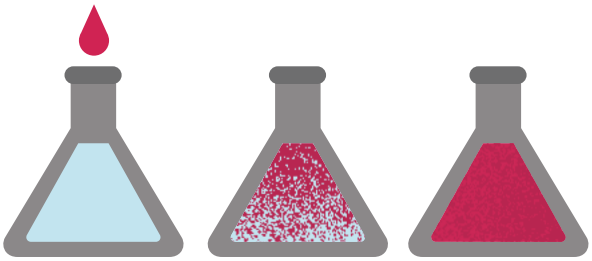
Your challenge

You need to be able to impress your friends with your knowledge of potions! Sometimes all it takes is just one magic drop to completely transform a solution!

Use trial and error to turn water bright pink with just one 'magic' colourless drop!

WHAT YOU NEED TO DO

1. Watch the demonstration by your Club leader. Think about how this happened.
   - how could you get the same result, but with sodium hydroxide rather than pure sodium
   - to make things trickier: can you make the solution so that all it takes is ONE drop of sodium hydroxide to turn the colourless solution pink
2. Collect a beaker of water and safety glasses, put on the safety glasses.
3. Add about five drops of phenolphthalein to the water.
4. Begin to add some sodium hydroxide (slowly). What happens?
5. Can you figure out how to get to a point where all it takes is one more drop of sodium hydroxide to turn the solution pink?
6. Practise – impress your friends with your magic solution!



FUN FACTS

1. Can't go to the toilet? Phenolphthalein is also used as a laxative!

2. Red cabbage is a natural indicator. When you first cut it open, you'll notice it's blue. Add some water to it to see the colour more clearly. Add some vinegar (acid) and it turns bright red! Lemon juice works too!
3. Bored of the colour of your flowers? Change the acidity of the soil. Hydrangeas will grow pink in alkaline soil but change to blue in acidic soil – they are natural indicators!
4. Marine biologists use this technique to maintain environments in fresh water and marine aquariums, ensuring the survival of precious marine life.

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CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

2 Care of magical creatures

Objective

In this activity, students observe a snake formed from fire. They will explore how incomplete combustion of glucose yields carbon.

TOPIC LINKS

Chemistry: combustion

TIME

45 minutes

RESOURCES AND PREPARATION

- disposable pie tin or metal bowl
- sand
- ethanol (excess) flammable
- sucrose or (4g)
- bicarbonate of soda (1g)
- 2 small beakers or weigh boats (to weigh and mix dry ingredients)
- splints
- matches
- fume cupboard (recommended)

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity.

This activity is best done as a demonstration, but if the Club leader finds it appropriate, it could be performed by students in a fume cupboard.

Keep ethanol in a secured vessel and away from flames. All should wear safety goggles. Excess ethanol fumes are flammable and can cause irritation. The process of combustion should take place in a fume cupboard. Pupils are not to start combustion outside the fume cupboard.

DELIVERY

1. Snakes are big part of the wizarding and witchcraft world, but they are hard to get hold of – could we make our own?
2. Explain that students will be seeing the process of combustion used to make a snake. They will they need fuel, heat and oxygen.
3. If incomplete combustion occurs what colour do students expect the snake to be?
4. Use a well ventilated lab or fume cupboard when carrying out this activity. It is best done as a demo, but under close supervision, students can carry it out, following the instructions on the student guide.
5. Monitor students as they soak ethanol into the sand, or perform these steps as a demo.

TIPS

1. You can change the quantities (keeping to the 4:1 ratio), and have students create baby snakes in mince pie foil tins. If using larger quantities, it is best done as a demonstration only.
2. Attach the splint to a metre rule to allow students to light the snake from a distance. Ensure a fume cupboard is used.
3. If a fume cupboard is not available, this experiment can be done as a demonstration on an open bench in a well-ventilated room. Do not allow multiple snakes to be formed outside of a fume cupboard due to an excess of ethanol fumes.

DIFFERENTIATION IDEAS

Support: give students the exact quantities to use.

Challenge: tell students that they need to use icing sugar and bicarbonate of soda in a 4:1 ratio and to calculate the quantities on their own. Do not allow students to perform the activity on their own if using quantities greater than listed in the Resources and preparation section.

EXTENSION IDEAS

Have a class discussion:

1. What is causing the snake to push upwards and outwards?
2. What is the purpose of the bicarbonate of soda?
3. What type of combustion is happening here and how do you know?

STUDENT GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

2 Care of magical creatures

Your challenge

Magical creatures are a standard part of witch and wizard life. No witch or wizard is complete without a snake, but snakes are in limited supply – and besides, they need to be magical!

Combine sucrose and baking soda with ethanol to create a dancing magic snake.

WHAT YOU NEED TO DO

1. Wearing safety glasses, collect a pie tin and fill it with sand, creating a mound of sand in the middle of the tin.
2. Use your finger to make a small indent in the middle of the mound, wash your hands afterwards.

YOU OR YOUR CLUB LEADER WILL THEN:

3. Weigh 1g bicarbonate of soda with 4g sucrose in weighing boats and mix together by pouring them from one boat to the other until fully mixed.
4. Using a plastic pipette add just enough ethanol over the indent you've made ensuring the sand is damp.
5. Add the mix of icing sugar and bicarbonate of soda to the indent.
6. Place the pie tin into a fume cupboard (this can also be done in a well ventilated laboratory) and pull the screen down so it is nearly closed.
7. Use a splint on a metre rule and carefully light the sand next to the sugar mixture – making sure everyone stands at least 1 metre away.
8. Be patient! Wait a few minutes and watch as the snake is born and begins to dance!

FUN FACTS

1. snakes can be found on every continent in the world except Antarctica.
2. snakes are deaf to airborne sounds, and they 'hear' by picking up vibrations through their jawbones.
3. did you know there's a difference between venom and poison? Venom is injected through a bite or a sting while poison has to be inhaled or swallowed – both are pretty terrifying!

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Is there witchcraft and wizardry in the real world?

3 Herbology

Objective

In this activity, students extract limonene from an orange. Students will explore how to use distillation apparatus to isolate substances.

TOPIC LINKS

Chemistry: separation techniques

TIME

60 minutes

RESOURCES AND PREPARATION

- distillation apparatus (see diagram)
- oranges (2 per group)
- grater
- anti-bumping granules
- distilled water
- measuring cylinders
- spatula
- dropping pipette
- separating funnel (optional)
- test tubes

If distillation apparatus are unavailable, the following can be used:

- heat proof mat
- bunsen burner
- clamps, stand and boss heads
- side arm boiling tube
- bung to fit boiling tube
- bent delivery tube
- rubber connection tubing
- a small test tube
- a 100 ml beaker
- a wooden block or inverted beaker to act as a platform

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity.

Safety goggles should be worn.

This is a challenging activity that requires close supervision. If it is felt this experiment is too challenging for pupils, it can be shown as a demonstration instead.

Ensure this is run by an experienced member of science staff or that the club leader has practised it beforehand with the help of a colleague familiar with distillation.

DELIVERY

1. Discuss with students how plants provide a wealth of useful substances to us, but we need to be able to unlock them from the plant.
2. Discuss ways we can extract things from plants.
3. What separation techniques have students learned about at school? (Filtration, chromatography, evaporation, distillation).
4. Assist students as they set up their apparatus according to the instructions in the student guide.

TIPS

1. Add clips to the joints to minimise breakages.
2. Use a conical flask to collect the distillate to see the aqueous and oil layers more clearly.
3. Some schools might have microscale kit for this activity, which works well and is quicker to set up and pack away.
4. If there are not enough sets for pupils to do this in groups, have one ready to demonstrate and elicit from pupils how it could all fit together. What connects with what?
5. Why are there holes on the condenser? Encourage pupils to build the equipment and to link the equipment to the aim of the experiment (isolate limonene).

DIFFERENTIATION IDEAS

Support: set up the distillation apparatus for students or have the equipment necessary for each group divided into trays. Allow students to closely follow the diagram to set up their experiment.

Challenge: have a demo of distillation apparatus set up and allow students to independently select the correct equipment for distillation. Add red herring equipment to challenge them.

EXTENSION IDEAS

1. Students could investigate what happens if they keep heating the mixture in the conical flask.
2. Ask students under what circumstances would distillation not be a useful separation technique?
3. **Demo:** Set up three test tubes, each containing limonene, cyclohexane and cyclohexene respectively. Add a few drops of bromine water to each of the test tubes. Ask students what this shows about the structure of limonene.

STUDENT GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

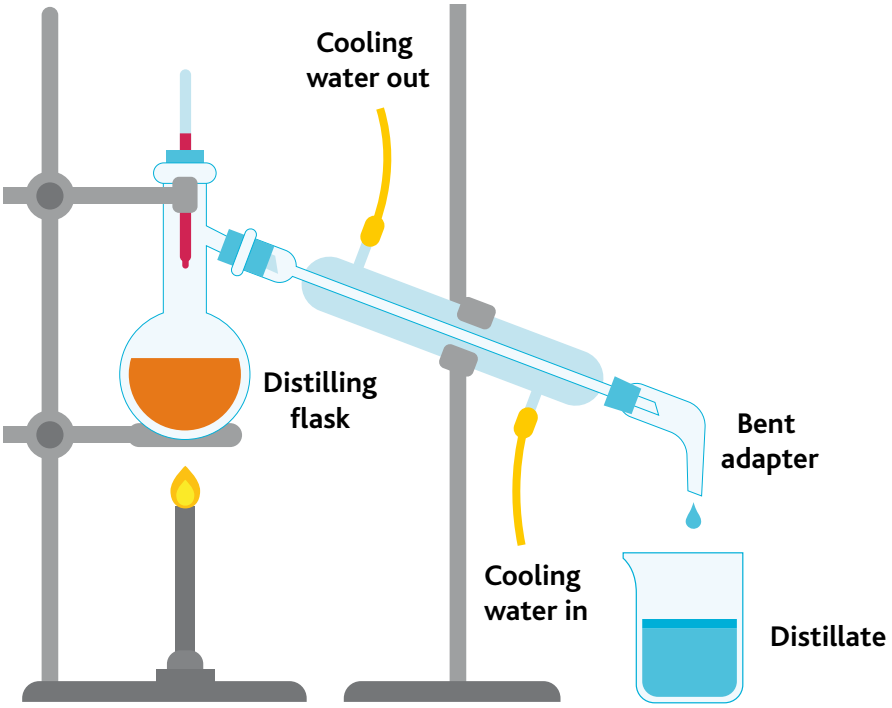
3 Herbology

Your challenge

Some of the ingredients that wizards and witches need are locked away deep inside plants. We need to become experts at extracting them!

Use distillation to extract precious limonene from an orange.

WHAT YOU NEED TO DO

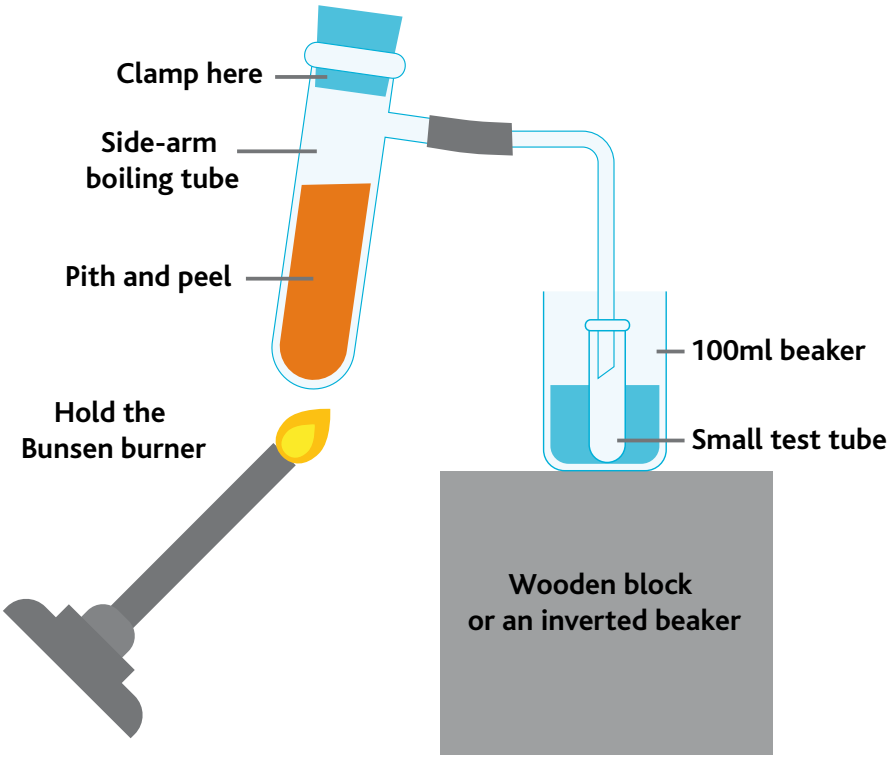


1. Collect your safety goggles and grate the rind from two oranges.
2. Measure out 100 cm^3 of distilled water into a 250 cm^3 round bottomed flask.
3. Add 1 spatula of anti-bumping granules to the flask.
4. Set up the distillation apparatus as shown above, making sure to put the orange rind in to the flask.
5. Heat the flask so the liquid in the round bottomed flask gently boils.
6. Collect about 50 cm^3 of distillate in the measuring cylinder. Notice there are two layers.
7. Use a dropping pipette or a separating funnel to isolate the oily limonene in a test tube.
8. Use your hand to carefully waft the fumes from the oil to smell. **Do not sniff the oil directly!**

Alternative method: small-scale distillation to extract precious limonene from an orange.

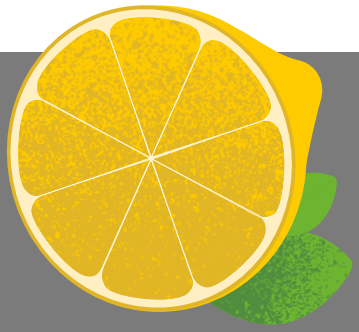
WHAT YOU NEED TO DO

1. Collect your safety goggles and grate the rind from two oranges.
2. Fill your side arm boiling tube to about two thirds full with the rind.
3. Add enough water to the side-arm boiling tube to just cover the rind.
4. Set up the equipment as shown in the photograph and the diagram. There is no need to use a thermometer.
5. Light the Bunsen burner. Carefully hold it at an angle so you can gently move it up and down the boiling tube to slowly heat the contents. If the water starts to boil, stop heating for a few seconds until the boiling subsides. It is important the rind is gently heated and not burned – or you will lose your precious limonene!
6. After about 5 minutes, heat more rapidly so that some of the water and limonene transfer over to the test tube.
7. Continue until the test tube is about half full.
8. Turn off the Bunsen burner.
9. You should have two layers in your test tube.



10. Use a dropping pipette or a separating funnel to isolate the oily limonene in a test tube
11. Use your hand to carefully waft the fumes from the oil to smell. **Do not sniff the oil directly!**

FUN FACTS



1. Limonene exists in many fruits – oranges, grapefruit, lemons and limes. It's a natural insecticide, protecting the fruit from nasty bugs.
2. Limonene is used in cleaning products, cosmetics, food flavourings and aromatherapy.
3. Some scientists think that limonene could have cancer fighting abilities! They think that when eaten it increases the number of cancer-killing enzymes in your liver.
4. Limonene exists as an isomer. This means there are two versions of the compound, but with different properties. The other isomer is found in mint and used to make menthol-flavoured gum.
5. Scientists and engineers at desalination plants use distillation as part of the process of turning sea water into drinking water.

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Is there witchcraft and wizardry in the real world?

4 Alchemy

Objective

In this activity, students watch as a copper coin is transformed into gold. Students will explore how to make metal alloys and see how they exhibit different properties.

TOPIC LINKS

Chemistry: metals, alloys, non-reversible reactions

TIME

60 minutes

RESOURCES AND PREPARATION

- 24 g Sodium Hydroxide Pellets (CORROSIVE)
- goggles for club leader and students
- disposable gloves
- 5 G zinc powder (highly flammable, dangerous for the environment)
- steel wool
- 100 Cm^3 distilled water
- copper coins
- metal tongs
- 250 Cm^3 beaker
- measuring cylinder
- bunsen burner
- tripod
- gauze
- stirring rod
- weigh boats
- scales
- spatula
- hot plate

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity. Safety goggles should be worn.

This practical is a **demonstration only**. It is imperative it is practised and carried out but a qualified Chemist or Science expert only.

Gloves should we worn by the club leader. Zinc powder must be kept away from naked flames.

DELIVERY

1. Start a group discussion about alchemy:
   - what is alchemy? (a medieval practice concerned with transforming one type of matter into another – usually trying to turn other materials into gold)
   - do students think it's possible
   - have people in the past fooled people into thinking they have made gold
   - what is fool's gold (Iron pyrite)
2. Metals can be mixed to make alloys. Some alloys have properties like shine and colour that are very similar to gold, and therefore can be mistaken for it!
3. Demonstrate turning copper coins to gold.

METHOD

1. Ensure you are wearing safety goggles and gloves, and measure out 24 g of solid sodium hydroxide.
2. Measure out 100 cm^3 of distilled water into a 250 cm^3 beaker and add the sodium hydroxide. Stir the solution – it will get warm.
3. Use a hot plate to heat the solution until it boils.
4. Turn the hot plate off.
5. Measure out 5 g of zinc powder into a weigh boat.
6. Show students the hazard card for zinc powder and ask them why a hot plate has been used prior to this step. (Zinc is highly flammable, so a Bunsen burner would be very hazardous. A hot plate reduces the risk of fire.)

TIPS

1. Allow pupils to bring in their own copper coins and to get them ready for plating by rubbing them down with the steel wool.
2. Allow pupils to complete the final step of heating the silver coin in a Bunsen to turn it to gold.

7. Carefully add the zinc powder to the sodium hydroxide solution.
8. Ask students what they observe.
9. Ask students to use steel wool to scrub a copper coin until it is shiny.
10. Without touching the hot solution, drop the shiny copper coin into the zinc solution. It will sit on the powdered zinc at the bottom of the beaker.
11. After 1 minute, use a pair of tongs to flip the coin so both sides have been in contact with the zinc powder.
12. Remove the coin using tongs and rinse the coin under running cold water. You should now have a silver coin!
13. Clear away all hazardous materials.
14. Using a pair of tongs, allow students to heat the coin in a Bunsen flame for a few seconds to turn it gold. Don't overheat or you'll lose the gold!
15. Repeat from step 9 for any further coins.

DIFFERENTIATION IDEAS

Support: demonstrate the procedure first before students heat the coin with the Bunsen burner.

Challenge: ask students to explain what is happening at each step and why you are following that procedure.

EXTENSION IDEAS

1. Explain to students that the zinc is being oxidised. What does this mean in terms of electrons? What is happening to the copper?
2. Ask students to name the alloy they have made.

USEFUL LINKS

FACT OR FICTION? Scientific American article about turning lead into gold

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Is there witchcraft and wizardry in the real world?

4 Alchemy

Your challenge

The ultimate goal for any witch or wizard is to make gold – can you see it with your own eyes? It's a complicated process but if the instructions are followed exactly you will have lots of shiny metal by the end of the session.

Turn copper coins gold.

WHAT YOU NEED TO DO

1. Watch as your Club leader measures out 24 g of solid sodium hydroxide. Why are they wearing gloves?
2. What happens when the sodium hydroxide pellets are added to the distilled water?
3. Read the hazard card for zinc powder. Why do you think a hot plate was used to heat the sodium hydroxide solution?
4. What key terms could you use to describe what you observe as the zinc powder is added to the sodium hydroxide solution? What kind of chemicals do you think are being made here?
5. Use some steel wool to scrub your copper coin until it is shiny.
6. Why does your club leader use tongs to add the coin to the solution?
7. Now the coin has been run under cold water – what do you see?
8. Set up a Bunsen burner and heatproof mat.
9. Using a pair of tongs, heat your coin in a Bunsen flame for a few seconds to turn it gold. Don't overheat or you'll lose the gold!

FUN FACTS

1. For hundreds of years alchemists tried to make the philosopher's stone, a mythical substance that would change base metals like lead into gold.

- they didn't know that lead and gold were different atomic elements – the periodic table was still hundreds of years away
- nuclear physicists can turn one element into another, and have managed to turn a base metal into gold – but the process is very expensive and only produces a tiny amount of gold

2. Copper and zinc mixed together make an alloy called brass that can be mistaken for gold

- the more zinc there is in brass, the lighter it becomes. Musical instruments made from brass contain a lot of zinc
- radiators have brass fittings because brass doesn't rust. You'll notice the brass is quite dark on radiators and is actually called 'red brass'. This is because it has a much higher percentage of copper than usual (85%) which makes it non-corrosive

3. Civil engineers will choose specific alloys to suit their purpose – for example, the suspender ropes (metal ropes) on a suspension bridge need to be the perfect mix to make the alloy extremely strong but not too brittle

STEM CLUBS

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CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

5 Invisibility cloaks

Objective

In this activity, students make materials disappear by suspending them in liquids of a similar refractive index. Students will explore the idea of refractive index and how similar materials refract light in similar ways.

TOPIC LINKS

Physics: refraction, lenses, refractive index

TIME

30 minutes

RESOURCES AND PREPARATION

- a large beaker made from borosilicate glass
- vegetable oil (2 L)
- smaller glassware made from borosilicate glass (test tubes, beakers, etc.)

OR

- vegetable oil (50 ml)
- ignition tubes made from borosilicate glass
- paper towels

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity. Safety goggles should be worn.

DELIVERY

1. Discuss how we get things to disappear. Use examples of animals in the natural world (e.g. chameleons), and think about how humans (or witches and wizards) could create similar camouflage.
2. Invisibility cloaks could work in the real world: if two objects refract light in the same way, they will look the same as each other.
3. Explain that vegetable oil and glass have a similar refractive index.
4. Follow the instructions in the student guide. Assist students as they carry out the experiment.

TIPS

1. This will only work with vegetable oil, not any other oil.
2. Glassware must be made from borosilicate glass such as Pyrex.

DIFFERENTIATION IDEAS

Support: give students the vegetable oil only and get them to experiment with getting various glassware to disappear.

Challenge: give students a variety of oils/liquids and objects of different materials. Set them the challenge of getting the objects to disappear in the liquid.

EXTENSION IDEAS

1. Research the refractive index of other liquids and solid materials to see if the same effect can be achieved with something else.
2. Allow students to present and explain this phenomenon to peers at the end of a science lesson. Put your thumb over the end of a glass funnel and place it upside down in the oil, when you remove your thumb it will magically disappear! You can also already have some objects in the bottom of the beaker (you won't be able to see them) and then magically pull them out!

USEFUL LINKS

- Metamaterials article from the Institute of Physics
- BBC article about invisibility cloaks
- Guardian article about invisibility cloaks

STUDENT GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

5 Invisibility cloak

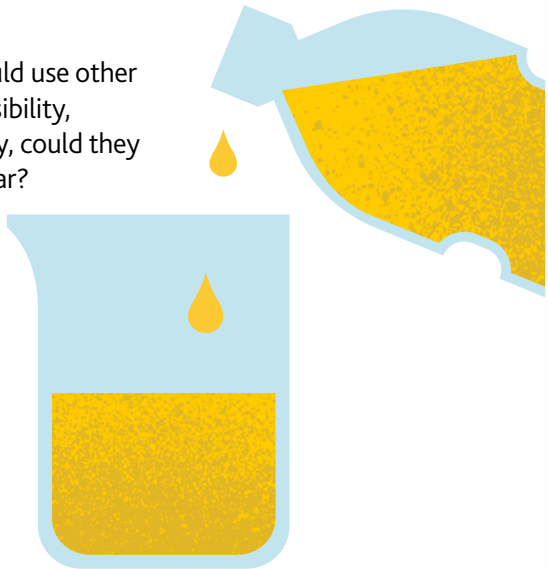
Your challenge

Witches and wizards can make themselves invisible. But how do they do it? And can we do it too? It's all about matching the right materials together.

Watch the glassware in your lab disappear as you experiment with materials of a similar refractive index.

WHAT YOU NEED TO DO

1. Fill a large beaker with vegetable oil.
2. Select some glassware to add to the beaker of oil.
3. Add the glassware ensuring it is filled with oil and completely submerged.
4. Watch as the object disappears.
5. Reach into the beaker to reveal the object that was hiding!
6. Investigate how we could use other methods to create invisibility, consider the practicality, could they conceal a person or a car?



FUN FACTS

1. Invisible technology currently uses metamaterials made of tiny mirrors (on the nanoscale), which reflect light in different ways to make things 'disappear'.
2. Some of our top scientists and engineers work for the military. They are looking into whether 'invisibility cloaks' made of metamaterials could hide approaching aircraft or troops.
3. One of the best substances for metamaterials is gold, so invisibility cloaks could be pricey!

STEM CLUBS

NUMBER 1 FOR STEM

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

6 Levitation

Objective

In this activity, students build a levitating hovercraft. Students will explore the idea of equal and opposite forces, causing an object to rise upwards.

TOPIC LINKS

- Physics: equal and opposite forces
- Engineering: applying force laws to suit a purpose

TIME

40 minutes

RESOURCES AND PREPARATION

- a CD
- a balloon
- super glue or hot glue gun (wear gloves to prevent getting stuck)
- sports water bottle cap
- bag clip

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity. Safety goggles should be worn.

DELIVERY

1. Discuss what levitation is. In terms of forces, what is happening? (An upward force counteracts the downward force of gravity on an object.)
2. Ask students to draw a force diagram showing the equal and opposite forces acting during levitation.
3. Explain that if we can achieve these forces an object will levitate!
4. Assist students as they make a hovercraft, following the instructions on the student guide.

TIPS

1. When gluing the cap to the CD, line the table with some kitchen towel to catch any spillage.
2. Stick the bottle top to the top side of the CD so that the bottom has minimal friction.
3. You could ask technicians to stick the caps to the CD in advance to prevent sticky situations!

DIFFERENTIATION IDEAS

Support: assist students as they follow the step-by-step instructions.

Challenge: give students all the equipment and get them to independently figure out how to make the CD levitate.

EXTENSION IDEAS

1. Get students to use a pin to create some more holes in the sports cap. Investigate the effect this would have.
2. Have students levitate the balloon on different surfaces. Ask them what they notice.

USEFUL LINKS

- Japan's Maglev
- Magnetic Levitation Lifts Impurities from Pharmaceuticals

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Is there witchcraft and wizardry in the real world?

6 Levitation

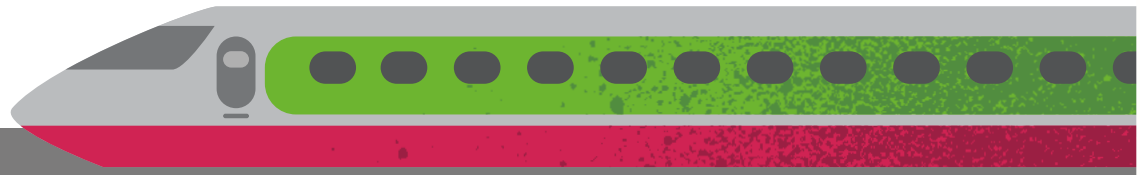
Your challenge

A key skill for witches and wizards is to get objects to fly and move in mid-air. Can you do the same thing?

Use the power of equal and opposite forces to get an object to hover.

WHAT YOU NEED TO DO

1. Position a sports drinking bottle cap in the middle of a CD. Ensure the CD has its smoothest side down.
2. Use the super glue or glue gun to stick the cap to the CD. Leave it to set.
3. Blow up a balloon and hold it shut with a bag clip.
4. Ensure the bottle cap is in the open position.
5. Attach the end of the balloon to the bottle cap.
6. Remove the bag clip and watch the CD hover and zoom across the table! (You may need to give the CD a little nudge).
7. Investigate methods of transport that use levitation and discuss how practical it would be to have hover boards or levitating cars. What are the limitations and how could they be overcome?



FUN FACTS

1. Magnetic levitation (maglev) is a new transport technology that allows vehicles to move across the ground without touching it. This technology is planned to be used on high speed rail.
2. The Shanghai Maglev Train, also known as the Transrapid, is the fastest commercial train in the world with a top speed of 430 kilometres per hour.
3. The pharmaceutical industry is using the idea of levitation to levitate drugs so they can be made and delivered to the body more efficiently.

STEM CLUBS

NUMBER 1 FOR STEM

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

7 Apparition

Objective

In this activity, students build a device that will reflect an image in multiple ways, creating a hologram.

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity. Safety goggles should be worn.

Take care when cutting acrylic. Students should use a sharp knife, steel ruler and cutting board. Pre-cut the acrylic into shapes if there are any concerns over students cutting.

TOPIC LINKS

- Physics: light, optics
- Design and Technology: make
- Maths: quadrilaterals
- Engineering: application of science

TIME

50 minutes

RESOURCES AND PREPARATION

- sharp knife
- cutting board
- scissors
- graph paper
- pencil
- steel ruler
- clear acrylic
- tape
- smart phone or computer, depending on school policy

DELIVERY

1. Have a class discussion:
   - is it possible to make things appear somewhere else?
   - what advantages would this have?
   - if we can't physically make ourselves suddenly appear somewhere else, what would be the next best thing?
2. Explain to students that it is possible to manipulate the laws of simple reflection so that an object appears to be somewhere different to the source.
3. Assist students as they follow the instructions on the student guide.

TIPS

1. Clear acrylic is readily used in DT departments. A CD case or a clear empty drink bottle can also be used.
2. If students struggle with using a sharp knife and cutting board, have the pieces of acrylic pre-cut for them.

DIFFERENTIATION IDEAS

Support: provide the templates for the trapezoids for students, or guide them step by step through how to draw one.

Challenge: give students the dimensions of the trapezoid but allow them to independently draw these on graph paper.

EXTENSION IDEAS

1. Ask students which images work best. Why do they think this is?
2. Get students to research how this technology could be used. Where would it be useful?

USEFUL LINKS

- Search YouTube for "3D hologram videos" to test your contraption
- BBC video about holographic announcers at Luton
- Wired article: BBC builds a 'holographic' TV to see how we may watch shows in the future

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7 Apparition

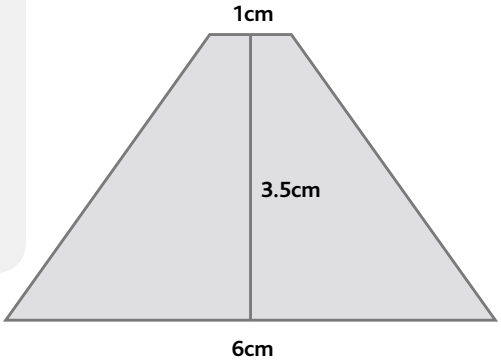
Your challenge

Abracadabra! Every wizard and witch needs to be able to make something appear at the flick of their wand (or smart phone). Make an image magically appear somewhere else – in 3D!

Use your phone, plastic and some nifty maths to create your own hologram.

WHAT YOU NEED TO DO

1. Use your pencil and graph paper to draw a trapezium as outlined in the diagram above.
2. Cut the template out and use it to trace four identical trapezium shapes on your clear acrylic sheet.
3. Carefully use a sharp knife and cutting board to cut your four acrylic trapeziums out.



4. Tape together the four trapeziums to make a pyramid. You will see there is a small square hole at the top of your pyramid. Add more tape if necessary to hold the pyramid together.
5. Load up a suitable hologram video on your smartphone or computer.
6. Place the pyramid in the middle of the screen of the phone, with the small opening down. If using a computer, hold the pyramid so the small opening is touching the middle of the computer screen.
7. Turn off the lights.
8. Watch your 3D image appear!

FUN FACTS

1. Holograms are really hard to copy. This is why we see so many holograms on bank notes, passports and driver's licenses in order to prevent counterfeit products.
2. Scientists were excited at the discovery of the 2,300-year-old 'Lindow Man', as his skull could unlock many scientific mysteries. The body was so fragile that they created a holographic image to study instead of touching the bones!
3. Military engineers have developed aircrafts that use holograms so pilots don't have to take their eyes off the windshield and can read data from instruments projected by hologram.
4. You can see holographic announcers at airports and stations.
5. Holographic engineers are working on television sets that could be projecting actors into your living room in the next decade.

STEM CLUBS

NUMBER 1 FOR STEM

CLUB LEADER GUIDE: SUITABLE FOR AGE 11-14

Is there witchcraft and wizardry in the real world?

8 Charms

Objective

In this activity, students change the colour of flowers to one of their choice. Students will explore the biology of a plant demonstrating the position of the xylem in a plant.

TOPIC LINKS

Biology: plants

TIME

30 minutes + checking daily

RESOURCES AND PREPARATION

- white carnations, daffodils, roses, chrysanthemums, or gerberas (minimum 2 per student)
- test tubes (2 per student)
- test tube racks
- food colouring (a variety of colours)
- sharp knife or scissors
- cutting board

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity. Safety goggles should be worn.

Take care when cutting the stems.

DELIVERY

1. Have a group discussion:
   - what factors help determine a person's favourite flower? Colour? Scent? Shape?
   - why are some species of the same plant different colours?
   - how could we manipulate plants to change their colour to one of our choice?
   - what part of the plant should we tackle? (The xylem carries water and nutrients from a plant's roots to its leaves and petals, so this will also bring dye to the petals. The xylem is found throughout the stem).
2. Assist students as they follow the instructions on the student guide.
3. The plants will need to be viewed each day over the next week.

DIFFERENTIATION IDEAS

Support: get students to prepare test tubes or beakers of their desired coloured water and put a whole stem in each individual test tube or beaker.

Challenge: students can cut the stem in half and suspend the carnation, so half the stem is in one colour and half in a different colour. This will show that the xylem exists throughout the entire stem.

TIPS

1. Trim 0.5 cm off the stem every two days to ensure maximum uptake of water.
2. Fresh, light coloured flowers work best.

EXTENSION IDEAS

1. Ask students whether the uptake of some colours is faster than others. Why is this?
2. Do different species of flower have different rates of uptake? How could they measure this?
3. Investigate other liquids e.g. coloured juice drinks, fizzy drinks. Does this work? Students could try cola versus a clear fizzy drink.
4. Investigate what happens when you take the flower out of the cup and it dries. Does the colour stay or go?
5. Investigate what happens if you put one side of the flower in salt water and one in plain water. How would the flower look different?

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Is there witchcraft and wizardry in the real world?

8 Charms

Your challenge

A charm is a spell that adds certain properties to an object or creature. Charm your friends with magic by creating coloured flowers.

Dissect a flower and force coloured water up the stem to create a personalised bouquet.

WHAT YOU NEED TO DO

1. Collect two flowers.
2. Remove all leaves off the stem so only the stem and flower head remain.
3. Carefully cut the stem at an angle. Trim it so that the carnation can stand upright in a test tube.
4. Use a knife or a pair of scissors to carefully cut down the length of one of the stems, from about 5 cm below the flower all the way to the bottom. Your stem should now be split into two with the flower holding it together.
5. Put both flower stems in water so they do not dry out.
6. Prepare two test tubes with coloured water of your choice (use food colouring for this) and place them next to each other in a test tube rack or on a bench.
7. Take your split flower and put one half of the stem in one test tube and the other half in a different coloured test tube.
8. Add your remaining flower to a test tube containing plain water. This is your control.
9. Set the flowers in natural sunlight and check them four times a day for five days.
10. Trim the stems (about 0.5 cm every 2 days).
11. Watch the charm take place!

FUN FACTS

1. Xylems act just like a straw: water evaporates from the leaves (like when a person sucks from a straw) and more water is drawn up through the xylem to replace it.
2. Ever crunched into a juicy stick of celery? All that juice is from your teeth breaking into the xylem.
3. Food colouring isn't the only way to change the colour of a flower – changing the pH of the soil will do this too. That's why the same plant species can be different colours when they are in soils of different acidity.

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9 Get CREST Discovery Awards

By completing all nine activities in this resource pack, your STEM Club members can get a CREST Discovery Award.

ABOUT CREST

CREST is a scheme that inspires young people to think and behave like scientists and engineers. It is student-led, flexible and trusted. CREST helps young people become independent and reflective learners. With no set timetable, projects can start whenever you want, and take as long as you need.

HOW TO GET YOUR CREST DISCOVERY AWARDS

It's easy to get your members' Discovery Awards, simply:

1. Sign-up for a free account - https://my.crestawards.org/
2. Have each member complete a CREST Awards Discovery Passport
3. Create a project eg. "How do they make movies", "Movie music" or "Witchcraft and wizardry"
4. Upload names
5. Upload two or three passports and any accompanying work
6. Assess individuals, have they:
   a. Completed around five hours of work on the project?
   b. Participated fully in the project?
   c. Reflected on their learning?
7. Type in your delivery and payment details.

TAKING THEIR WORK FURTHER

If members want to take activities further, they can work towards a CREST Bronze or Silver Award.

CREST Bronze Awards require around ten hours of enquiry, project-based work, and Silver Awards require thirty hours of work at GCSE or equivalent standard. Using one of the activities for inspiration, they choose a question or topic to investigate.

Guidance on how to run CREST Bronze and Silver Award projects is available on the CREST Awards website www.crestawards.org.

STEM CLUBS

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STEM Clubs Programme, led by STEM Learning

Achieving world-leading STEM education for all young people across the UK.

For more information on the programmes and publications available from STEM Learning, visit our website **www.stem.org.uk**