NATIONAL SCIENCE & ENGINEERING WEEK
nsew.org.uk

Get engineering!

Tomorrow's Engineers

Part of the British Science Association's National Science & Engineering Week activity pack series. **www.nsew.org.uk**

BRITISH SCIENCE ASSOCIATION

Department for Business, Innovation & Skills

Tomorrow's Engineers

NATIONAL SCIENCE & ENGINEERING WEEK nsew.org.uk

Tomorrow's Engineers is a careers programme led by EngineeringUK and the Royal Academy of Engineering, delivered through a broad partnership between business and industry, the engineering profession, activity delivery organisations and schools, working together to inspire learners.

Our long-term objective is to reach every state-funded secondary school in the UK to:

- improve awareness about engineering and what engineers do, among pupils, their teachers (and parents)
- enthuse young people about engineering and the career opportunities available
- encourage young people to make the subject choices that keep open the routes into a career in engineering.

The Tomorrow's Engineers initiative brings engineering into the classroom to give young people the chance to get hands on with engineering and ask questions about what real-life engineering jobs entail. This is underpinned by curriculum-linked careers information and resources, and an ambassador programme.

The Tomorrow's Engineers careers resources include a 'What is Engineering?' PowerPoint presentation, postcards for students, a leaflet for parents, career route maps and a resource pack for teachers. All of the resources are available online: **http://www.tomorrowsengineers.org.uk/resources.cfm.**

Our website also provides further information for teachers about how to get involved with STEM activities. To find out more visit: **http://www.tomorrowsengineers.org.uk/get_involved/teachers.cfm**

Get engineering!

The Tomorrow's Engineers activities in this pack aim to introduce students aged 11-14 to different sectors of engineering and the engineering principles involved. Each of the challenges are fun and hands-on and can be easily run in the classroom or at science clubs, during National Science & Engineering Week, or at any time in the year.

This pack also includes information for teachers on where to go for related activities, careers resources and to find out more about real-life engineers.

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Desert Island Drinks

Filtering water challenge

For details of all routes into engineering go to www.tomorrowsengineers.org.uk

Desert Island Drinks

Tomorrow's Engineers

What do you need to know?

Organiser's notes

This activity helps students to understand the principles of filtration, and enables them to discuss how the composition of different materials enables them to filter different particles.

Guidance

- Read through the instructions and familiarise yourself with the procedure
- Use the discussion topics below to introduce, summarise and provide context to the activity
- Make sure that students have had sufficient time to read and understand the directions

Discussion topics

- Why do different materials filter out different particles?
- What is the most effective way of filtering particles of differing sizes? What makes a good filter?
- What domestic, commercial, industrial or other processes might require filtration, either now or in the future?

Curriculum links

KS3 – 3.2	Chemical + Material Behaviour
KS4 – 2.2	Chemical + Material Behaviour
KS3 SC 2.2 a, b	(Critical understanding of evidence)
KS3 SC 1.1	(Scientific thinking)
KS3 SC 1.2	(Application and implication of science)
KS3 SC 2.1	(Practical enquiry)
KS3 Ma 2.3 a-e	(Interpret and evaluate)

Get involved

Further reading and resources

If you've enjoyed this activity try 'Water for the World' workshops developed by Engineers Without Borders and the Arup Cause. These aim to help teachers educate young people about the challenges of sustainability, development and securing safe drinking water.

Meet some Thames Water apprentice engineers (case studies).

Tomorrow's Engineers

A water engineer is part of our Green Crew. Do the whose Crew Are You? quiz to find out which crew you're in!

Find out more about careers in engineering

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Desert Island Drinks

Tomorrow's Engineers

Are you ready for an engineering challenge?

Desert Island Drinks

Whilst on your way to a once-in-a-lifetime holiday, the plane runs out of fuel and is forced to ditch in the middle of the Pacific Ocean. You are stranded on a desert island with only your crate of homesickness-busting British household supplies for company. It's going to be a week until rescue arrives, and although you can happily eat coconut soup, coconut curry and coconut bolognese day and night, you'll need water. The only fresh water on the island, however, is in a muddy, pea-infested pond. You're going to have to become a water engineer if you're going to last long enough to be rescued.

Your Task

...is to apply water treatment principles to create a device that will remove solid particles of different sizes from dirty water, leaving water that is clean enough for you to survive on whilst stranded on the desert island.

Get involved

Without a regular supply of fresh water you will become dehydrated, and your body will do some funny things. Lose just 5% of your body's water and you'll feel sleepy and nauseous. Lose 15% and your skin will wrinkle, your vision will fade and you'll become delirious. Lose more than 15% of your body's water and you'll probably die. OK, so we're talking funny "weird" rather than funny "ha ha".

Although it's possible to survive on unfiltered water, the risk of disease is far higher, so when faced with dirty water the best approach is to make it as clean as possible. People have been filtering water for over 3,000 years, with ancient Greek, Egyptian and Sanskrit texts describing processes for filtering water using gravel and sand. Hippocrates, known as the "father of medicine", invented a cloth filter bag to remove sediments from water that was to be used in medicine.

In the future demand for water is likely to become a more and more important issue, affecting entire nations. For example, if Sudan were to dam the Nile, then Egypt could face water shortages and alternative sources of water would need to be found, and made fit for human use. One of the things that water engineers will need to do in the future is develop practical technical solutions to problems caused by climate change and demographic pressures. This includes clean water provision, wastewater treatment, sewerage and flood defences.

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Desert Island Drinks

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Get engineering...

Activity Materials List

An empty plastic bottle (1L or 2L)
Scissors
A high-sided tray or dish
Water (in a container!)
A selection of 'contaminants'
(such as sand, glitter, different size beads)
Cardboard
Glue
A pint glass
A selection of filtration materials
(such as satsuma bags, cardboard, tissue paper, cotton wool, cloth)

Instructions

First, make some dirty water:
Place a layer of each of the contaminants into the pint glass. Add water and stir so that the contaminants are well mixed. Note how the different contaminants mingle together (this is the easy bit!).

Next make a water filtration device:
Taking care, use the scissors to cut the bottom off of an empty bottle. Cut a horizontal slit into the side. Cut two pieces of cardboard to the shape of the bottle and cut a large circle in the centre of each piece. Between each piece place a layer of filtration material. Next, glue the pieces of cardboard together. Turn the bottle upside down and place in the first of your filtration materials. Repeat this process down the bottle.

Finally, filter the water:
Place the water filtration device into the tray or dish, hold it steady and then pour the dirty water in at the top. Marvel at science in action, then grab a coconut and prepare to defend your precious technology from thirsty castaways.

Tips

- Does the order in which you place the filters make a difference?
- What makes a good filtration material?
- When you're finished the water will be filtered but not purified, so don't drink it. You're not *really* dying of thirst on a desert island.

Follow-on activities

- There is likely to be some particles left in your filtration device, you can test you water to see how clear it is?
- Examine your filtered water – can you see any particles? Shine a torch through it – does it look clear and colourless, or tinted?
- Pour some of the unfiltered water through a coffee filter paper. Examine the paper, count the number of particles and note it down. Pour some of the resulting filtered water onto another coffee filter paper, count the number of particles and compare it with the first result.
- Could you clean the filters in your filtration device and filter the water through your device again? What happens when you do this a second time?

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Snacktory Factory

Chocolate assembly line

For details of all routes into engineering go to www.tomorrowsengineers.org.uk

Organiser's notes

Snacktory Factory

Tomorrow's Engineers

What do you need to know?

Organiser's notes

This activity will help students to understand the principle of automated engineering processes and will enable them to discuss the differences between bespoke production and mass production.

Guidance

- Read through the instructions and familiarise yourself with the procedure
- Use the discussion topics below to introduce, summarise and provide context to the activity
- Make sure that students have had sufficient time to read and understand the directions.

Discussion topics

- What are the benefits of automated production methods?
- Which types of products are best suited to mass production?
- Are there any products that would not be suited to mass production? Why?
- How will snacks be manufactured in the future?

Curriculum links

KS4	Forces and motion
KS3 SC 1.1	(Scientific thinking)
KS3 SC 1.2	(Application and implication of science)
KS3 SC 2.1	(Practical enquiry)
KS3 SC 2.2 a, b	(Critical understanding of evidence)
KS3 Ma 2.3 a-e	(Interpret and evaluate)
KS3 D&T 1.1b	(Apply knowledge to design products

Get Involved

Further reading and resources

There is loads of engineering involved in making chocolate. Find out more about the manufacturing process at Divine Chocolate.

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Find out how Toffee Crisps are manufactured (video case study)

Find out more about careers in engineering

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Student section

Snacktory Factory

Tomorrow's Engineers

Are you ready for an Engineering Challenge?

Snacktory Factory

There's a fantastic new employment opportunity going in the local chocolate factory. The job is lead process engineer – the pay is great, there's free dental insurance, and the main perk is that you get to eat all the chocolate you like (hence the free dental insurance). They're going to give the job to whoever can build the best chocolate bar assembly line.

Your task

…is to build a prototype assembly line that demonstrates how you could add toppings to chocolate bars automatically and efficiently – without contaminating the chocolate by touching it with your hands. You need to show the people at the chocolate factory that you know how to create products quickly and cheaply.

Get Involved

An assembly line automates the chocolate production process, and process automation is a well-established method of increasing production output, reducing costs and ensuring standardisation and consistency – all of which are key issues in commercial manufacturing.

Assembly lines were popularised during the Industrial Revolution in the 1800s. Following the electrification of factories in the United Stated of America at the end of the 19th Century, the Ford Motor Company popularised the concept of production line mass production.

Modern automated processes increasingly use robotics, as this enables production quality to be controlled more easily, it allows 24-hour production, and robots can operate in ways and under conditions that humans would find difficult – on the microscopic scale, in vacuums, at high or low temperatures, or in a sterile environment. Process engineers work to design, test and improve the commercial and industrial equipment and technologies used in these processes.

Advances in materials science mean that the future of automated production could involve printing process-specific parts and components on-site using 3D printers, with common systems that can be adapted – a process known as "rapid manufacture". This could even allow machine parts to be printed in situ for use in a space station, or even on another planet. With scarcity of resources becoming a more and more important issue, manufacturing from recycled materials will become more and more important.

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Snacktory Factory

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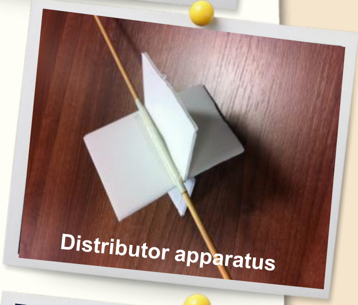
Get engineering...

Conveyor belt

Activity Materials List

- Cardboard or corex
- Empty plastic bottles
- Sticky tape
- Straws
- Blue Tack®
- Wooden dowels, (5 mm in diameter)
- Refuse sacks
- Play Dough®
- Scissors
- Toppings (such as glitter, beads, sequins)



Distributor apparatus

Instructions

First, make the conveyor belt apparatus

Make a hole in each end of the empty bottles, then poke a length of dowel through it so that it protrudes at each end. The whole should be small enough that the dowel doesn't move around, if it does you can make it smaller with Blue Tack®.

Next lay the bottles side by side, leaving a small gap in between.

Stand a piece of cardboard alongside them and mark on the cardboard the position of the dowels.

At each mark, cut a hole in the cardboard just large enough for the dowel to fit through.

Thread each piece of cardboard over the dowels, so that the bottles are held in place between them.

Cut a refuse sack into thin strips about 3 cm wide. Loop one of the strips around the ends of the first and second bottles, then tie it into a band.

Make sure it is tight. Do the same at the other end of the same two bottles.

Topping dropper

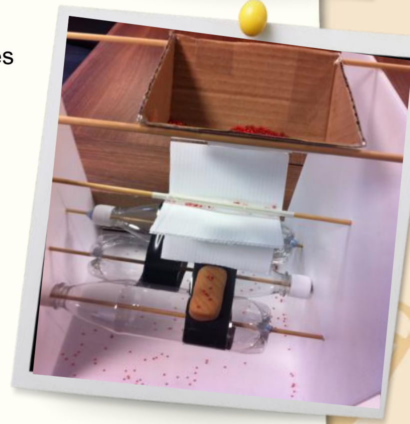
Assemble the conveyor belt apparatus

Repeat this step for the other bottles, but alternate the position of the bands between wide and narrow. Finally affix a short length of dowel to one of the protruding dowels, to act as a handle.

Next make the distributor apparatus:

Cut two panels of cardboard and cut a slit halfway along each. Slot the two pieces together to make a cross and affix a straw into each corner and a dowel in the centre.

Poke the dowel through the cardboard at a point high enough that the distributor has just enough room to rotate above the bottles. Repeat as many times as there are different toppings that you'd like to apply.



Now you need to make the topping droppers:

Cut the corner from a cardboard box at a 45° angle, then cut a hole or a series of holes part of the way along the edge.

Cut the cardboard at a 45° angle, then cut a hole in the edge

Repeat this for as many distributor apparatus as you have, then affix each dropper to the cardboard sides, directly above each distributor apparatus. Make droppers of different sizes and with different holes, to vary the flow of toppings.

Finally, top your chocolate:

Load the topping droppers with toppings, form your Play Dough ® into the shape of a chocolate bar, place it on the conveyor belt and crank the handle.

For details of all routes into engineering go to www.tomorrowsengineers.org.uk

Snacktory Factory

Tomorrow's Engineers

Get engineering...

Further Information

Tips

- The tension of the conveyor belt bands (the refuse sack strips) is key – too tight or too loose and the belt won't turn.
- The position of the distributor apparatus is important – too low and the machinery may become stuck, too high and the mechanism will not be triggered
- How does the shape and position of the holes in the droppers affect the distribution of toppings?

Follow on activities

- Automated processes are often easily extended and adapted. Many factories produce multiple products on the same production line – look out for similarities in design and packaging.
- The conveyor belt itself could be used to apply materials to an object – how could you apply textures or other materials to the rollers in order to imprint designs onto the bars? Could you print words on the bar? Could you print your own name?
- Could any other foodstuffs be topped (or filled) using the same machine? What adaptations might be required? Could the machine be used or adapted to carry out any other processes?

Make your own Play Dough

4.5 oz white flour	2 tbsp cream of tartar
240 ml warm water	2 tbsp cooking oil
2 tbsp salt	3 oz jelly

Mix all of the ingredients together in a small saucepan. Keep mixing until the lumps are gone. Heat over a medium heat, keep stirring until the mixture thickens into a ball of dough. This step may take a while, when it's ready you won't be able to stir it anymore.
Once it has finished cooking, place the dough on a floured cutting board and wait for it to cool.
Once it's cool (at least 20-30 minutes) knead it, adding flour, until it is no longer sticky.
You can now add food colouring to make the colours more vibrant, or even glitter.
When you have finished using the Play Dough you can store it in the refrigerator in an airtight container for a few weeks. If it becomes sticky just add more flour.

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Clever Copters

Fantastic fuselages

For details of all routes into engineering go to www.tomorrowsengineers.org.uk

Clever Copters

Organiser's notes

Tomorrow's Engineers

What do you need to know?

Organiser's notes

This activity will help students to understand the principles of propulsion, friction and stabilisation, and will give them an appreciation of how weak materials may be reinforced in certain combinations.

Guidance

- Read through the instructions and familiarise yourself with the procedure
- Use the discussion topics below to introduce, summarise and provide context to the activity
- Make sure that students have had sufficient time to read and understand the directions

Discussion topics

- What makes a bundle of spaghetti strong when a single strand is brittle and weak?
- What combinations of materials are both strong and light?
- How could materials be used to reinforce one another?
- Why use a glass bead (or other rounded spacer) between the washer and the propeller?
- Why attach the curled card to the fuselage?
- Why is safety so important? How will this change as transport changes?

Curriculum links

KS3 SC 3.1	(Energy, electricity and forces)
KS4	Forces and motion
KS3 SC 2.2 a, b	(Critical understanding of evidence)
KS3 SC 1.1	(Scientific thinking)
KS3 SC 1.2	(Application and implication of science)
KS3 SC 2.1	(Practical enquiry)
KS3 Ma 2.3 a-e	(Interpret and evaluate)
KS3 D&T 1.1b	(Apply knowledge to design products)

Get Involved

More engineering challenges…

If you have enjoyed this challenge and you if you have some K'NEX try their user group Helicopter Challenge.

Further reading and resources…

Find out what it is like to be a graduate engineer at Agusta Westland (video case study)
Find out about future aerospace engineering challenges (future challenges and careers).

Tomorrow's Engineers

An aeronautical engineer is part of our travel crew. Do the Whose Crew Are You? quiz to find out which crew you're in!

Find out more about careers in engineering

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Clever Copters

Tomorrow's Engineers

Are you ready for an engineering challenge?

Clever Copters

You work for a roll cage development facility, designing and building helicopter safety frameworks. In order to make these, factories make prototypes using materials that act in a similar way.

Your task

...is to design and build a model self-propelled, unpiloted helicopter that's strong but still light enough to fly – using materials that at first glance may not seem suited to aeronautical engineering purposes but can be used in prototypes. For example, you can use spaghetti which is strong and light like carbon nanotubes, and acts in a similar way.

Get involved

Materials engineers are always looking for ways to replace the component parts of a machine with materials that are lighter, stronger, easier to maintain, more plentiful or cheaper (or a combination of these factors). Where aerial vehicles are concerned, the lighter a material is, the better – the more something weighs the more fuel it needs to keep it in the air, and fuel costs money.

One huge breakthrough was the development of carbon fibre in the 1950s and 1960s which, when combined with lightweight polymers, led to a material that was light and strong. The next such leap forward in materials science is likely to be the use of carbon nanotubes – tiny tubes of graphite – to reinforce polymers, which produces a material even stronger than carbon fibre. Beyond that are 'smart materials' – substances that react to external forces and change their behaviour accordingly.

Designers are increasingly looking at ways to remove the pilot from the aircraft in the future, more and more aircraft are likely to be unpiloted, either flown by pilots from the ground or controlled by setting waypoints. These craft are designed to conduct missions that are "dull, dirty and dangerous" which would be undesirable or impossible for a human pilot – such as conducting 24-hour surveillance, monitoring contaminated areas or transporting supplies through a war zone.

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Further resources

Clever Copters

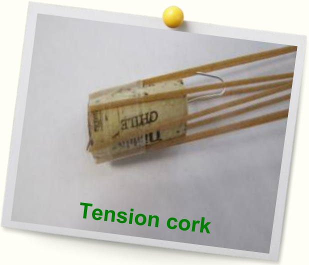
Tomorrow's Engineers

Get engineering...

Activity Materials List

A selection of fuselage materials (such as spaghetti, coffee stirrers, cardboard tube, drinking straws)
A propeller
Two small corks (or one cut in half)
A washer
Two paperclips
A small glass bead
Sticky tape or masking tape


Propeller cork


Tension cork


Clever Copter!

Instructions

First assemble the tension cork:
Make a hole through the middle of the corks, this needs to be big enough for a paper clip to move freely. Unfold one of the paperclips, leaving a J-shaped hook at one end, and thread it through the cork. Fix the end of the paper clip to the end of the cork. This is your tension cork.
Tie elastic bands together end to end until you have a single band that can be gently pulled taut to a length of around 30 cm (two will probably be sufficient). Loop this band onto the J-shaped hook on the tension cork.
Next construct the fuselage: select from the fuselage materials available to create a firm, hollow framework around the cork. Thread the elastic band through the framework and fix the tension cork to the end of the cylinder.
Assemble the propeller cork: now you need to make your propeller cork: as before, unfold the paperclip leaving a J-shaped hook at one end, make a hole through the cork, and thread the paperclip through the hole. Slide a washer over the straight end, and then a glass bead, then affix the propeller. Hook the elastic band over the J-shaped hook in the propeller cork, and attach the cork to the fuselage.
Finally, add a stabiliser fin: roll a piece of card into a cylinder, then tape it to the fuselage. You are now ready to conduct your first flight, just wind the propeller and set your pilotless helicopter soaring into the air.

Tips

- Remember, keeping the weight down is important (when was the last time you saw a fat sparrow? Exactly).
- Which material (or combinations of materials) provides the most strength for the least weight?
- Try the helicopter without the curled card attached to the fuselage; what happens? Why do you think this is?
- Try the helicopter without the spacer bead; what happens? Why do you think this is?

Follow-on activities

The only job of an aircraft is to carry a payload in the air – commercial aircraft carry passengers, fighter aircraft carry munitions, and surveillance aircraft carry cameras, radars and other detection systems.

- What is the maximum weight of payload that your helicopter can transport?
- Are any trade-offs required in terms of strength or propulsion power when carrying additional weight? Do you need to compromise the design in any way – use lighter materials, or a stronger elastic band?

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