Royal Academy of Engineering

THIS IS ENGINEERING

OUR EXISTENCE

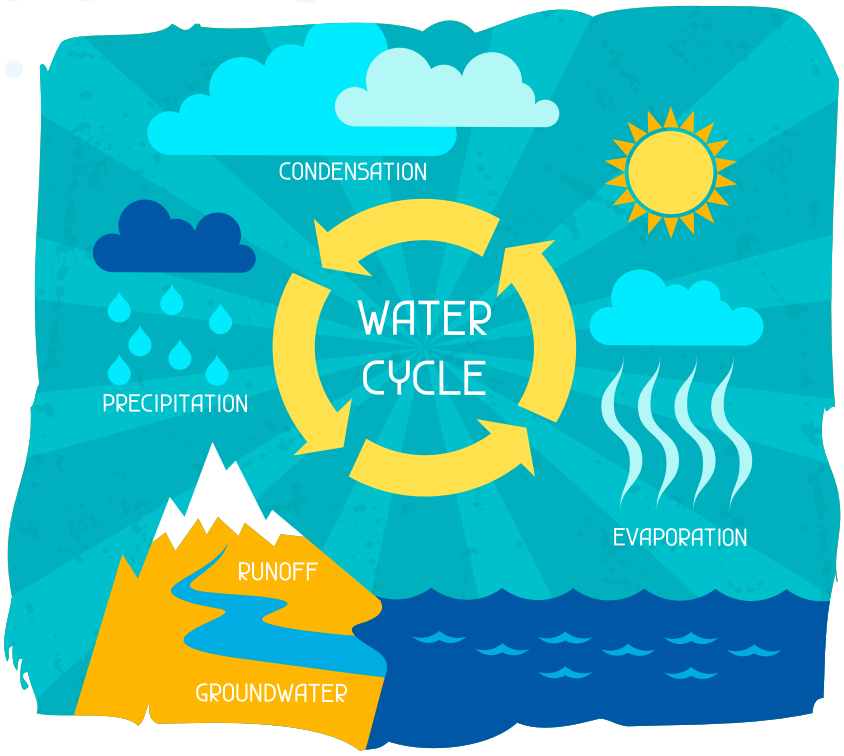
Monsoon

This resource explains how an indigenous population created an engineering solution to problems they encounter in extreme rain, such as knups, a type of umbrella that allows them to continue farming during monsoon season.

MONSOON

As water is heated by the sun it evaporates into water vapour that rises into the air.

When the air cools it condenses around some dust or other particles in the air, which are called condensation nuclei. As more of these small droplets collect together they become visible as clouds. If these cloud droplets collide and merge they become too heavy and fall under gravity as raindrops.



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Activity 1

Making a cloud in a jar.

To make a cloud in a jar you will need:

- A large beaker
- Kettle
- Water
- Ice cubes
- Black paper or card cut to the height of the beaker
- Matches or Bunsen burner and splints
- Large zip lock bag

Method

1. Firstly, wrap the black paper around the beaker and tape it so that you can still see into the beaker.
2. Boil the kettle and fill one-third of the beaker with the boiled water.

3. Pick up your zip lock bag and half fill it with ice.
4. Light the match, or splint, and hold it sideways over the beaker for five seconds; then carefully drop the match, or splint, into the beaker.

5. Cover the top of the beaker with the bag of ice. Make sure your bag fully covers the top of the beaker but does not touch the hot water.

Special thanks to Year 7 students at Southfield School for Girls for their contribution to writing this method.

6. After a few minutes you should see a cloud form. Lift the bag and watch your cloud rise.

Things to think about:

- Why do we need to put a lit match into the beaker?
- What are the dangers of sulfur dioxide, a gas released when natural gas is burnt to produce electricity, being the condensation nucleus for the droplets?

EXTREME RAIN

The Meghalaya region in India holds the records for the wettest and second wettest place on Earth.

The village of Mawsynram receives an average of 11,873 mm of rain per year, which is over three times the average rainfall for the whole of the UK. Most of this rainfall occurs during monsoon season, between June and September. In Cherrapunji, the average annual rainfall is 11,430 mm but despite this there are often droughts in the area outside of the monsoon season.

During monsoon season, it can be difficult for farmers to work and stay dry at the same time. In Meghalaya and other regions of India, people use a traditional umbrella called a knup. Knups are made from banana leaves on a frame of bamboo and are worn rather than carried. This allows the wearer to use their hands, and because of the shape, the knup doesn't blow away in the wind.

Activity 2

In small groups you will be given the following project brief:

Design an umbrella to be used in the UK. The umbrella should be hands-free or allow people to use technology, and storm proof.

Alamy.com

Part 1

First your team should create an initial design. When you create your design you should think about:

- What can you learn from the design of the knup?
- What products are there already on the market? How is your design different?
- How much will your product cost?
- How will you make sure the umbrella is waterproof?

Part 2

Conduct market research.

One member of your team should take your idea to other groups to get feedback on your design.

Part 3

Create a detailed design.

This should include:

- What materials might be used and what the budget is.
- Can it be manufactured (in school)?
- How would the product be marketed?

Then, make a prototype of your umbrella and use a watering can to test whether it is waterproof and a fan to test if it is windproof.

HYDROPHOBIC MATERIALS

Hydrophobic materials appear to repel water, causing droplets that barely touch the surface to form.

Leaves on a lotus flower are superhydrophobic, which gives the leaf self-cleaning properties.

Engineers have studied this property and found ways to replicate the effect for human benefit. Hydrophobic materials are often used to remove oil from water and manage oil spills, and many engineers and scientists are looking into more possible uses for hydrophobic and superhydrophobic materials.

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STRETCH AND CHALLENGE

In your teams, evaluate your umbrella design.

How can modern materials or technologies be used to improve the product? For example you could try making your prototype from hydrophobic materials, or using a hydrophobic spray to coat the umbrella.

Make a second prototype and test under the same conditions as your first design. How is this design better?

HUMIDITY

Humidity is a measure of how much water vapour there is in the air; the more humid it is the more water vapour there is in the air.

Monsoon season is preceded by increased humidity, which can be uncomfortable or even dangerous. The increased humidity means the body is not able to cool itself effectively. The primary means of controlling core body temperature, called thermoregulation, for humans is sweating; the body is cooled when sweat evaporates from the skin. However with the increased water vapour in the air, this process happens at a lower rate which can result in overheating. This increased body temperature can result in fatigue, dehydration, cramping or even heat exhaustion.

Activity 3

Design a humidity warning system for farm workers in humid conditions. The system should be portable and warn workers when the humidity is reaching dangerous levels.

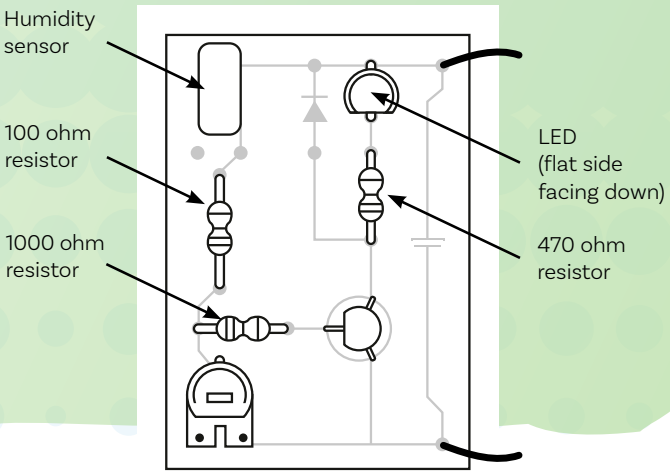
Part 1

First you need to build your humidity sensor. To build your humidity sensor you will need:

- Printed circuit board (PCB)
- BC548 transistor
- Humidity sensor
- 1KΩ resistor
- 100Ω resistor
- 470Ω resistor
- Standard LED
- 5K potentiometer
- Battery connector
- 9V battery
- Soldering iron

Solder the components to the PCB following the diagram (right):

Test your humidity sensor in different humid conditions; you may need to adjust the potentiometer so that the LED comes on at the right humidity.



Part 2

Use your humidity sensor to design a warning system for farm workers. The system should be portable and warn workers when the humidity is reaching dangerous levels.

EXTREME CREATURES

Not all scientists consider tardigrades, a microscopic animal, to be extremophiles because they are not adapted to live in extreme conditions. However they can survive in a variety of extreme conditions.

Tardigrades are most commonly found in moist environments and have been found all over the world: in hot springs on top of the Himalayas, under layers of solid ice, and in ocean sediments. Tardigrades have also survived the vacuum and radiation in space.

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Activity 4

Tardigrades can be found in the UK. A great place to find them is in moss.

To view tardigrade, you will need a microscope and some moss.

- Collect some moss and place in a petri dish.
- Soak in water (preferably rainwater or distilled water) for 3–24 hours.
- Remove and discard excess water from the dish.
- Shake or squeeze the moss/lichen clumps over another transparent dish to collect trapped water.
- Use a micropipette to transfer tardigrades to a slide, which can be observed with a higher power under a compound microscope.

You can also see how tardigrades can survive in extreme conditions, for example the extreme heat of a Bunsen burner.

- Collect some dry moss.
- Heat over a Bunsen burner.
- Place in a petri dish and soak in water.
- Remove and discard excess water from the dish.
- Shake or squeeze the moss/lichen clumps over another transparent dish to collect trapped water.
- Use a micropipette to transfer tardigrades to a slide, which can be observed with a higher power under a compound microscope.

The tardigrade will move fast so you must view them quickly.

NOTES FOR TEACHERS

ACTIVITY 1

It is important to use a lit match or splint as the smoke will act as the condensation nucleus for the water droplets to form around.

If sulfur dioxide, or nitrogen oxides, act as a condensation nucleus then acid rain will form. Acid rain is dangerous to plants and animals. The acid damages the waxy layer on the leaves of trees which protects the leaf. Acid in the soil also makes it more difficult for trees to absorb the minerals they need for healthy growth. Acid rain also makes rivers and lakes too acidic for some aquatic life to survive. Buildings can also be damaged by acid rain, which can erode the building materials.

ACTIVITY 2

Part 2

A good way to do this is through a timed round robin. One student visits the other project teams in turn. The remaining team members stay where they are, but provide feedback to the ideas presented by the visiting student. This works really well and helps teams to refine their ideas.

STRETCH AND CHALLENGE

Conduct a full risk assessment before using hydrophobic sprays. For this activity you will need access to hydrophobic materials or spray. Hydrophobic fabric sprays can be found in most supermarkets. Alternatively you could use waterproofing waxes or washing liquids as a demonstration of this effect.

ACTIVITY 3

Conduct a full risk assessment before using the soldering irons. The humidity sensor can be built without a soldering iron, using leads or solderless breadboard.

ACTIVITY 4

The tardigrade will move fast, especially after the light of the microscope is turned on, so encourage students to view the slides quickly.

Royal Academy of Engineering

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Together we're working to tackle the greatest challenges of our age.

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We're growing talent by training, supporting, mentoring and funding the most talented and creative researchers, innovators and leaders from across the engineering profession.

We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

Innovation

We're driving innovation by investing in some of the country's most creative and exciting engineering ideas and businesses.

We're building global partnerships that bring the world's best engineers from industry, entrepreneurship and academia together to collaborate on creative innovations that address the greatest global challenges of our age.

Policy & engagement

We're influencing policy through the National Engineering Policy Centre – providing independent expert support to policymakers on issues of importance.

We're engaging the public by opening their eyes to the wonders of engineering and inspiring young people to become the next generation of engineers.

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