Royal Academy of Engineering

THIS IS ENGINEERING IN THE NATURAL WORLD

Biomimicry

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

MILLY IS A CIVIL ENGINEER ON THE WATER ENGINEERING TEAM AT ARUP.

She works on projects designed to protect people from flooding. She works with natural elements such as rivers, lakes and trees, managing rainwater during storms.

Milly values the fact that her work benefits people and has a positive impact on the world.

Learn more about how engineers are finding ways to protect the planet by scanning the QR code or visiting the This is Engineering website.

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ACTIVITY 3
BIOMIMICRY

BIOMIMICRY TAKES ITS INSPIRATION FROM NATURE.

Engineers look to the natural world for ideas and inspiration, mimicking the blueprint of nature's engineering to tackle and resolve global challenges.

Learning from nature through biomimicry encourages a more sustainable approach to design engineering, fostering innovative and forward-thinking solutions..

LINKING TO THE CURRICULUM

Maths

Symmetry, patterns and tessellation: mathematical principles underlie natural forms, such as the Fibonacci sequence and the golden ratio.

Geography

Ecosystems and natural environments: how species adapt to their environments and inform sustainable practices.

Technology and innovation

The design process: looking at natural forms and systems as models for innovative products.

Physics

Aerodynamics and energy efficiency: how air resistance, drag, lift, energy transfer and conservation affect the movement of objects and systems.

A party blower resembles the distinctive shape of a coiled fern leaf. The leaves of a lotus flower are *superhydrophobic*, which gives them self-cleaning properties, which are mimicked in the material technology used for waterproof raincoats.

ACTIVITY 3.1 STRUCTURES IN NATURE

TIME TO INVESTIGATE

The hexagonal wax cells built by bees in their nests are strong and lightweight structures that contain and protect their stores of honey and pollen.

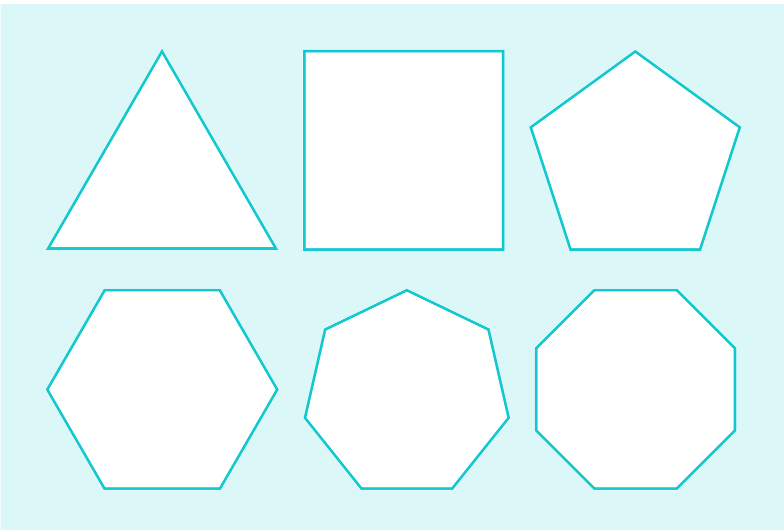
- Why do bees use hexagon shapes?
- What do you think makes the properties of the honeycomb design so successful?

TIME TO EXPERIMENT

The honeycomb is a **tessellation** of hexagons with hundreds of bees working together to repeat the pattern simultaneously.

Only three regular polygons tessellate. A regular polygon is a 2D shape where all interior angles and sides measure the same. Experiment to find the three regular polygons that tessellate.

- Why do you think the bees use the hexagon and not the other two shapes?



Hexagonal tessellating structure

All about the angles

Why do you think that these are the only regular polygons that tessellate?

Using the table, investigate the interior and exterior angles of each regular polygon and use this information to explain which regular polygons will tessellate.

Regular polygon	Size of each exterior angle	Size of each interior angle	Divide 360° by the interior angle *	Does this polygon tessellate
Triangle				
Square				
Pentagon				
Hexagon				
Heptagon				
Octagon				

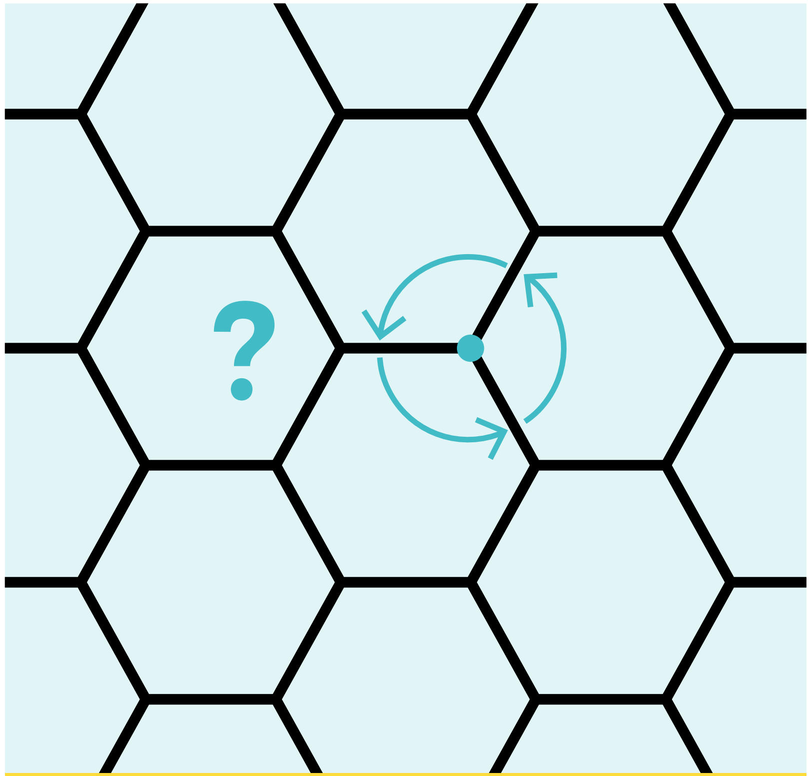
** If this is a whole number then the shape will tessellate*

ACTIVITY EXTENSION

Finding the volume of space within a material is an important part of the design and planning process.

Using what you know about area and volume, formulate an equation to calculate the volume of liquid that a single hexagonal cell can hold.

- How would you extend this equation to account for multiple cells?
- Does this equation remain valid regardless of the size of the individual cells within the material?



For a shape to tessellate, what is the sum of the angles around a point?

TIME TO BUILD

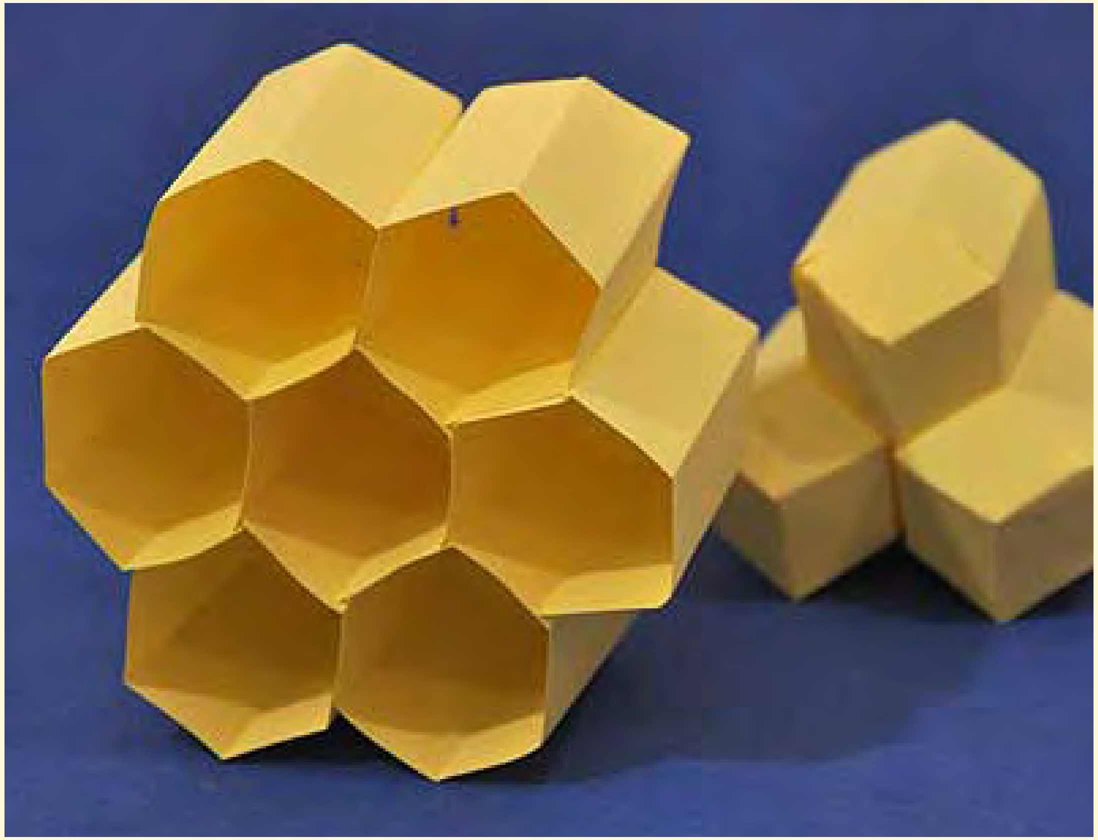
Build a honeycomb structure that can hold 3kg of weight.

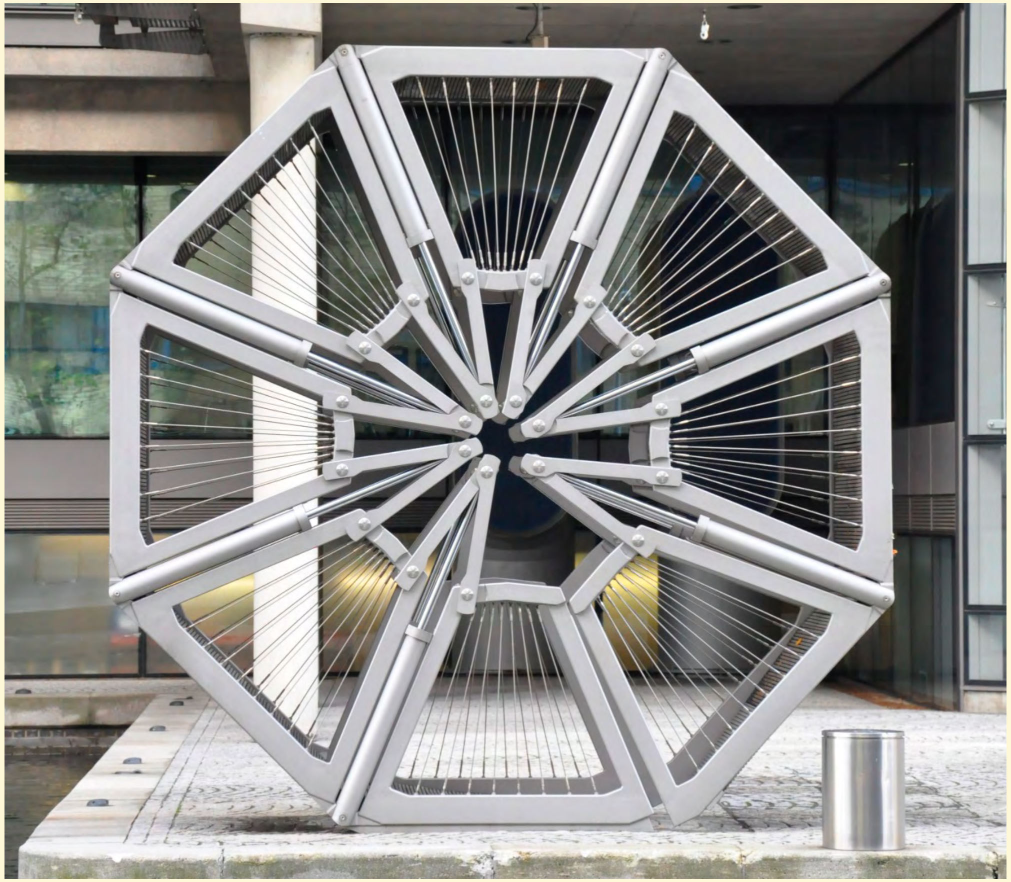
Suggested materials – newspapers, cardboard, tape, different types of paper.

Get creative. What can you **reuse and recycle** from around your school or home?

MATERIALS AND EQUIPMENT

- Ruler
- Calculators
- Cardboard
- Weights
- Sticky tape





Rolling bridge, engineered by Thomas Heatherwick – YouTube

ACTIVITY 3.2 DEPLOYABLE STRUCTURES

DESIGN AND ENGINEER A ROLLING BRIDGE

Setting the scene

A village is isolated from a hospital due to flooding caused by climate change. A bridge is needed to restore access but must be able to be deployed and retracted to accommodate changing water levels.

TIME TO PROTOTYPE

STEP 1: take a sheet of A4 card and divide it into five equal strips, cutting length ways.

To do this, measure the total width **(W)** of the card in centimetres 'cm' and divide by five.

What is the width of each strip?

STEP 2: measure the length **(L)** and give your answer in 'cm'. Next, divide the length of the card into sections to make a roll-up bridge.

Divide your value for **(L)** by the number of sections. Label your answer with the letter **(S)** for section.

What is the length of each section?

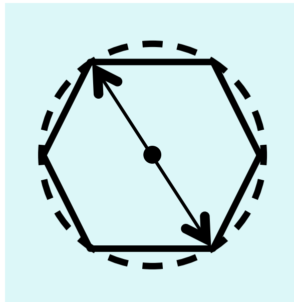
STEP 3: fold the card at each section and join the at each end to make the polygon shape.

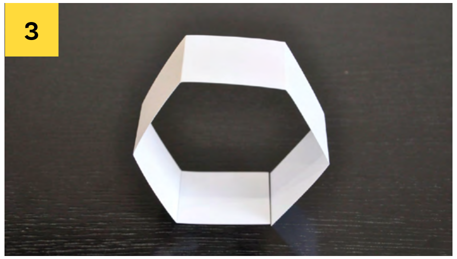
What shape is the polygon?

STEP 4: note how the polygon rolls and unrolls like Thomas Heatherwick's bridge.

STEP 5: we can estimate the diameter **(D)** of the circle that the polygon would fit inside.

(D) is a straight line that goes from one side of a circle to the other, passing through the centre. Measure the distance between two points. It may help to tape the ends of the polygon together.





TIME TO EXPERIMENT

Apply your engineering knowledge and develop your problem-solving skills by using maths to work out which of the polygons below would be most suitable for an emergency bridge crossing.

Use the diameter **(D)** and the formula for **Pi (π)** to calculate the circumference **(C)** of each shape.

- Which polygon would best span the distance needed for the bridge to reach the other side of the river?

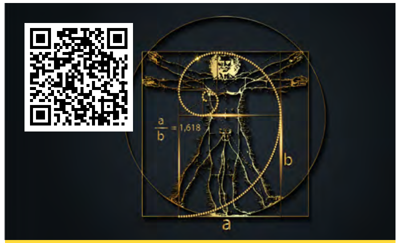
$$C = 3.14\ (\pi) \times D$$

ACTIVITY EXTENSION

Design and build a mechanical rolling bridge

In teams, find examples of engineering structures inspired by nature. Start by researching the **Fibonacci sequence** and the **Golden Ratio**.

Maths Fun – Fibonacci sequence



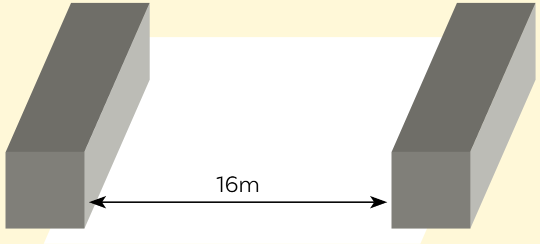
Maths Fun – Golden ratio

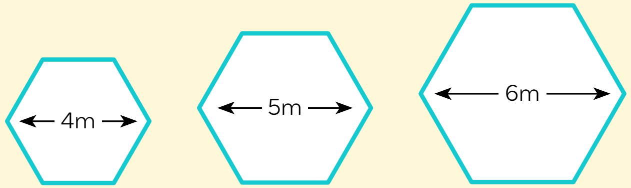
Brainstorm ideas and develop designs based on your findings.

Select your preferred designs or combination of ideas and create scaled models using construction and reusable materials. Consider factors such as strength, flexibility and ease of deployment.

Set up a testing area with simulated water levels, (such as water trays or sand) to test the functionality of the bridge models. Evaluate the strengths and weaknesses of each design.

How can modern materials and technologies be used to improve the bridge? For example, could a hydrophobic coating be applied to protect the structure from flood water?





Damage caused to a bridge by heavy rain and flooding.

Royal Academy of Engineering

The Royal Academy of Engineering is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

In collaboration with our Fellows and partners, we're growing talent and developing skills for the future, driving innovation and building global partnerships, and influencing policy and engaging the public.

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

What we do

Talent & diversity

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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