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Inspiring a new generation to love Science, Technology, Engineering and Maths

at home

Symmetry

As Emmy Noether was growing up in Germany at the end of the 19th century, she spotted symmetry all around her. She went on to make connections between symmetry and the conservation of energy. When she died, Albert Einstein called her a "significant mathematical genius".

This project highlights how symmetry is all around us. There are a selection of different tasks. You can choose to do as many as you like.

Maths	Explore symmetry in snowflakes
Technology	Investigate rotational symmetry
Chemistry	Making crystals
Biology	Explore symmetry in animals
Physics	Investigate centre of mass
Engineering	Explore symmetry in buildings

We would love to see photos so please share with #CSGatHome.

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Symmetry

Snowflakes

Story

Growing up in Bavaria, Emmy loved watching snowflakes fall. The crystals in snowflakes have six lines of symmetry. A shape has reflective symmetry if a line can be drawn so that either side of the line looks exactly the same. This is sometimes called a mirror line.

Equipment

- pencil
- ruler
- (optional) mirror
- scrap paper
- scissors

Instructions

- Is this always, sometimes or never true:
  triangles have exactly one line of symmetry.
  Check by drawing all of the lines of symmetry on an equilateral, isosceles, right-angled & scalene triangle.
- Draw 4 capital letters: A, E, H, X. Draw the lines of symmetry. Can you write a word that looks right on paper and in a mirror? Which letters can you use?
- Draw around a bowl and cut out a circle of paper.
- Fold the circle in half and then half again. Pinch the corner to mark the centre of the circle then unfold.

- Fold the semi-circle into 3 with a point at the centre.

- Cut bits away from the folded sides and curved edge.
- Unfold to reveal a snowflake

Glossary

All 3 angles in an equilateral triangle are equal

2 angles in an isosceles triangle are equal

1 angle in a right-angled triangle is 90°

All 3 angles in a scalene triangle are different

Questions

- How many lines of symmetry does your snowflake have?
- Snowflakes have six-fold symmetry.
  How could you improve your method to ensure your snowflakes always have six lines of symmetry?

Further tasks

- Making crystals
- Explore symmetry in animals
- Investigate centre of mass
- Investigate symmetry in buildings
- Explore rotational symmetry

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Symmetry

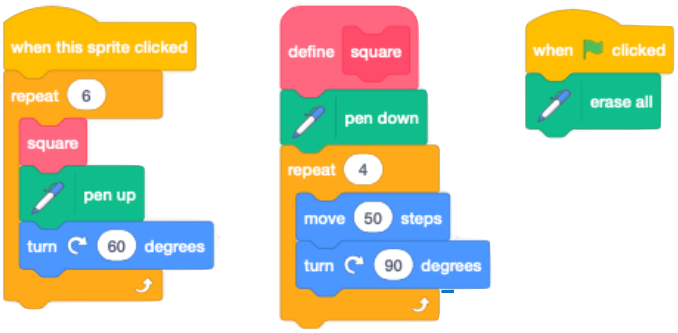
Rotational symmetry

Equipment

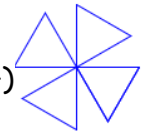
website: scratch.mit.edu

Instructions

- In "The King's Crown" project, we wrote code to draw different shapes. Can you remember how to draw a square? a rectangle? a triangle?
- Click the red 'My blocks' tab and define a block to draw each of those shapes.
- Sketch what you think this pattern will look like?



- Can you write code to make this pattern? (Remember there are 360˚ around a point)



If you are new to scratch, try remixing this project:
https://scratch.mit.edu/projects/394616828

Questions

- Can you write code to make a symmetrical pattern using an asymmetric shape (e.g. 6)?
- Can you change the size of the shapes?
- What is a mandala? Can you create one?
- Research a Sierpinski triangle. Does it have rotational symmetry? Can you draw one?

Story

Not only did the snowflakes that Emmy watched have reflective symmetry, they also had rotational symmetry.
Using loops in computer programs means a set of instructions (or algorithm) can be repeated many times. This repetition can be used to create beautiful symmetrical patterns.

Glossary

A shape that is rotated about its centre and looks the same in more than one position has rotational symmetry. The order of rotational symmetry tells you how many ways you can arrange it.

A snowflake has 6 lines of symmetry and its order of rotational symmetry is 6.

This shape has zero lines of symmetry but its order of rotational symmetry is 2.

Further tasks

- Explore symmetry in snowflakes
- Making crystals
- Explore symmetry in animals
- Investigate centre of mass
- Explore symmetry in buildings

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Symmetry
Making crystals

Equipment
- egg shells (at least two halves)
- egg box
- glue
- paintbrush
- table salt, epsom salts or sugar
- (optional) magnifying glass
- jug
- kettle
- food colouring
- newspaper or kitchen roll

Instructions
- Wash out the egg shells and wait for them to dry
- Paint the inside of the shells with glue then cover with salt or sugar. Put them in the egg box and let them dry.
- With an adult,
  - mix a few drops of food colouring with boiling water in a small jug.
  - add salt or sugar to the jug until no more dissolves and you can see solid at the bottom of the jug.
- When your supersaturated solution has cooled, carefully fill all but one of your egg shells.
- As a control experiment, fill the final egg shell with pure or coloured water.
- Leave the egg box on some newspaper or kitchen roll in a warm place for a few days. Check them every day. If the solution is taking too long to evaporate, carefully pour some out.

Research Ideas
- What is the same and what is different: graphite and diamond
- Can you draw their crystal structure?
- Can you name any other crystals or gems?
- Are there any crystals in your body?
- How are crystals categorised?

Story
Emmy knew that snowflakes were made from crystals. An ideal crystal is a solid with a regular shape that contains particles arranged in a repeating pattern - or lattice. Can you make some crystals with sugar or salt?

Glossary
A supersaturated solution contains more solute (e.g. salt or sugar) than can normally dissolve at that temperature.

A control experiment is carried out to check that the effect is caused by the variable you think. In this case, it is to see if crystals grow when there is no extra salt or sugar.

Questions
- Can you see any crystals? Can you see any symmetrical patterns? If you have one, look through a magnifying glass.
- Did crystals grow in the control?
- Would crystals grow if you did not paint the shell first? How could you test this?

Further tasks
- Explore symmetry in snowflakes
- Explore symmetry in animals
- Investigate centre of mass
- Investigate symmetry in buildings
- Explore rotational symmetry

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Symmetry
Animals

Equipment

- paper
- paint
- colouring pencils
- pencil
- marker pen
- (optional) mirror

Story

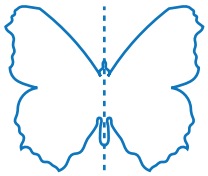
When the snow thawed and spring came, butterflies started to visit the garden. Emmy saw that animals display symmetry, too.

Instructions

- Research examples of butterflies and moths. You could use this Butterfly and Moth ID sheet from the Wildlife Trust.
- Fold a piece of paper in half and draw the outline of the wings on one half of the paper.
- Colour that half with paint.
- Fold the paper in half and press down.
- Open out the paper and add more detail to one side. Refold and press.
- Use a marker pen to draw the body and antenna once the paint is dry.
- If you have a printer, print an outline picture of a butterfly and colour it symmetrically.

Glossary

99% of animals have bilateral symmetry. This means that they have exactly one line of symmetry. However, there are ways in which the right side is not exactly like the left side. For example, the left lung is smaller than the right lung in humans so the heart can fit.



Animals with radial symmetry show a repeating patttern around a point.

Questions

- Some animals have more than one line of symmetry. Find some examples. What do they have in common? How does this radial symmetry help them to survive long enough to reproduce?
- Some animals are asymmetrical. How does this asymmetry help them to survive long enough to reproduce?
- How does bilateral symmetry help so many animals to survive long enough to reproduce?

Further tasks

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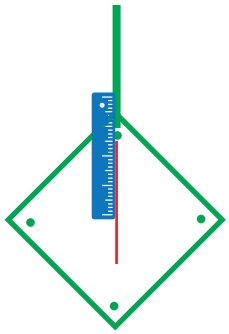
Symmetry

Centre of mass

Equipment

- thin card (e.g. cereal box)
- string
- hole punch
- weights (e.g. paperclips, sticky tack)
- pencil
- ruler

Instructions



- Cut out some different shapes (e.g. a square, a triangle, a circle, a crescent and a butterfly)
- Punch holes near each corner.
- Tie string to the hole and let the shape dangle.
- Use the ruler to continue the line of the string through the shape. Mark this with a pencil.
- Repeat for the other holes.
- The centre of mass is where the lines cross.
- Try balancing the shape at this point on a pencil.

Questions and Research Ideas

- Is there a relationship between the centre of mass and the lines of symmetry?
- How is a crescent different from the other shapes?
- You can change the centre of mass by adding weights to the shape. Can you add weights to the crescent so that it is possible to balance it on a pencil?
- Research how Dick Fosbury used the idea of centre of mass to set a new Olympic record.
- To make an object stable, where should the centre of mass be? Compare a car and a double decker bus.

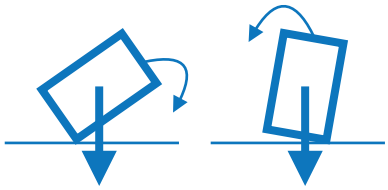
Story

In 1915, Emmy moved to Göttingen to study physics and maths. Her research needed her to understand centre of mass. Centre of mass helps us to design objects that are stable. Often the most stable objects are also symmetrical.

Glossary

The Ancient Egyptians used plumb lines to check that their constructions were vertical. A lump of lead was tied to a piece of string. The heavy weight was always pulled vertically down towards the centre of the Earth by gravity. Our name for it comes from the later Latin word for lead: plumbum.

An object is stable if it is difficult to push over. If the centre of mass is outside the base or edge on which it balances, the object is unstable.



Further tasks

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Symmetry

Buildings

Equipment

Choose your building materials. You might use:

- straws
- scrap paper
- building blocks
- spaghetti (uncooked)
- sticky tack
- tape
- playdough
- marshmallows (warning: this will make a sticky mess!)

Research Ideas

- What shapes make buildings strong and stable?
- What shape are the tallest buildings in the world?
- What is the superstructure of a building? What materials are used for this?
- Which of the materials that you have will be the most suitable?

Instructions

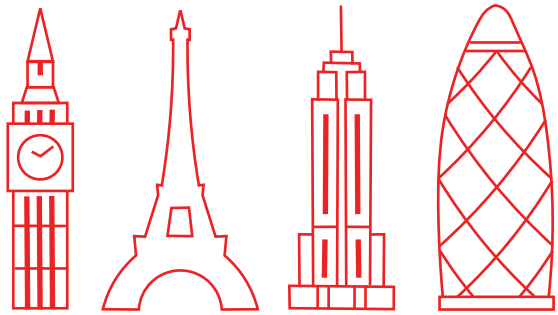
- Use your research to plan your skyscraper. What shapes will you use where? Can you draw it?
- Build the tallest building you can but make sure that it is stable.

Questions

- How stable would your building be in an earthquake? Gently shake the base; slowly increase the shaking.
- Is your building windproof? Try blowing it with the cold setting of your hairdrier.
- How strong is your building? How could you test this?
- Is your building symmetrical?

Story

In 1933, Emmy escaped from Nazi Germany and moved to the USA where there were many skyscrapers. Buildings need to be stable. Very often this means that they are symmetrical. Can you draw lines of symmetry on these buildings?



Glossary

The word skyscraper was first used in the 1880s to refer to buildings with more than 10 floors. Today, we expect skyscrapers to have at least 40 floors. At present the Burj Khalifa is the tallest building in the world at 828 metres.

Further tasks

- Explore symmetry in snowflakes
- Making crystals
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