MANCHESTER 1824
The University of Manchester

tiny tinkering tasks

EXPLORE 12 STARTER TASKS FOR

DEVELOPING ENGINEERING IN THE PRIMARY CLASSROOM

Short tasks to get your pupils hands-on and minds-on with engineering in primary schools?

These 12 Tiny Tinkering Tasks provide innovative and creative STEM starter lessons to introduce engineering into the primary classroom. Using the Engineering Habits of Mind and real-world engineering contexts these are great ways to get STEM started with your pupils.
Linked to the Tinkering for Learning research and development undertaken in partnership with the Royal Academy of Engineering.

PROBLEM FINDING

CREATIVE PROBLEM SOLVING

ADAPTING

SYSTEMS THINKING

IMPROVING

VISUALISING

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EXPLORE THESE TINY TINKERING TASKS

DEVELOP ENGINEERING HABITS OF MIND FOR AGES 5 - 11

CONTENTS

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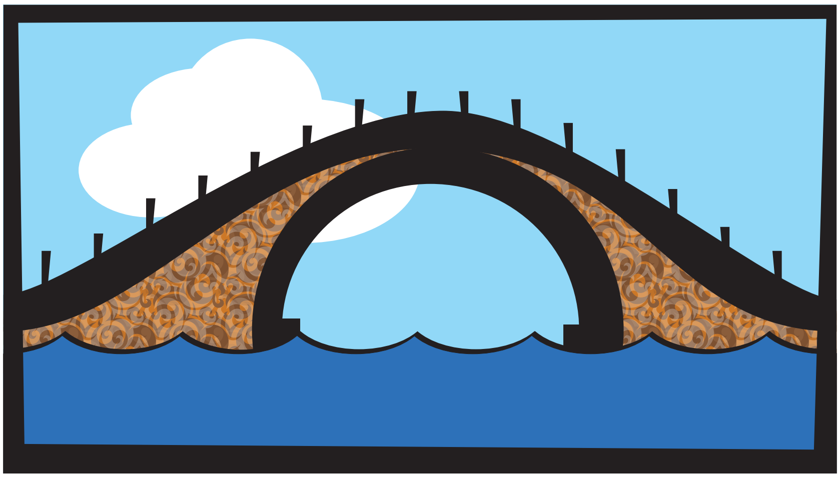
Task theme
Building Bridges

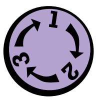


Task title
How does shape affect strength?

Learning outcomes

- To understand how the shape of a material can make it stronger.
- To appreciate that engineers must consider what shapes to use when designing structures.
- To work together to create and adapt models.

EHoM link



ADAPTING

Embrace an iterative approach alternating between plan (doesn't have to be written) and create.

EDP link

Key Stage/Year Group LKS2 – Year 3

Resources required

- Books to act as the supports (abutments) for the beam. Hardback school dictionaries or equivalent sized books are perfect for this activity. Children should be encouraged to construct piles that are the height of a school ruler (approximately 30cm).
- Sheets of A4 paper
- A selection of uniform objects to use as weights – this could be copper coins, multilink, counters – depending on what you have available in the classroom.

How to run the task

1. Engage the children in looking at a range of bridges – locally, UK-wide and globally. A useful source of information can be found at: https://kids.kiddle.co/Bridge
2. Explain to the children that they are going to investigate how the shape of a bridge affects its strength. To do this they are going to be using paper in different ways and testing the strength by seeing how much weight the structure can stand before it collapses.
   Note: To make this a fair test, the paper should always be placed lengthways, and the bridge abutments on each side (piles of books) should be 14cm apart.
3. Encourage the children to explore by first placing a single sheet of A4 paper onto the books and test its strength by placing coins in the middle until the bridge collapses. Use two pieces of paper and test again.
4. Use one piece of paper, but this time fold up the sides to make a walled bridge.
5. Make an arched bridge using two pieces of paper – one laid flat and the other folded into an arch shape underneath.
6. Using two pieces of paper, place one onto the supports and fold the other piece into ridges (corrugated) then place on top.

Top Tips

- Encourage the children to choose their own 'weights' and discuss why uniformity is important. This could lead to a conversation about how people weighed objects before standard units of measurement were invented.
- Ask the children to order their bridges in terms of weight bearing.
- Links to maths – draw a bar chart of the results.
- Extend – challenge the children to investigate bridge strength using corrugated cardboard. Cut two A4 sized pieces of cardboard from an old box with the corrugation running different ways – one along the length of the strip and the other across the width.

Place each piece on the supports and add weights as before. Does the way in which the corrugations run affect the strength?

- Support – have ready-made example of the different structures to show to children who are struggling.

Evaluate learning

- What have you found out about bridges?
- Which was the most successful design? Why do you think this is?
- What was it that you changed?
- What would be the problem of having a corrugated surface?
- If you change the distance between the supports, will the bridge support the same weight? Why do you think this is?

tiny tinkering tasks

Task theme

Materials Engineering

Task title

Can you make your own concrete?

Learning outcomes

• To understand that materials have different properties which makes them suitable for different jobs.
• To understand why concrete is a good building material.

EHoM link

SYSTEMS THINKING
Construct an object or tool requiring the successful interaction between components and subsystems.

APAPTING
Make objective judgements against success criteria and constraints.

EDP link

CREATE

IMPROVE

Key Stage/Year Group KS2

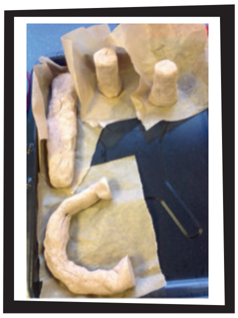
Resources required

• 1 cup of sand (250g)
• ½ cup of cornflour (125g)
• Handful of pebbles or gravel
• Boiling water
• Stainless steel bowl or Pyrex dish
• Saucepan

SAFETY NOTICE:
THIS ACTIVITY WOULD BE BEST DONE IN SMALL GROUPS WITH ADULT SUPERVISION, AS BOILING WATER IS INVOLVED TO INITIATE THE REACTION BETWEEN THE CORNFLOUR AND THE WATER.

How to run the task

1. Engage the children by asking them why it is important for engineers to choose the right materials for the job. Elicit their understanding by asking which materials might be used for building a load bearing structure such as a bridge and why? Which materials would certainly not be suitable? Why?
2. Explain that one of the most commonly used materials in the world is concrete. In fact, around 3 tonnes are produced every year for every single person. Discuss how concrete is made by mixing sand and small stones with water and cement, which hardens when it dries. This is because of a chemical reaction between the water and minerals in the cement.
3. Share the ingredients that the class will be using to make their version of concrete. What is different? Explain that the cornflour will be taking the place of the cement in this recipe.
4. Allow the children to explore making their own concrete, by following these steps:
   - Mix the sand and cornflour in a stainless-steel bowl. This needs to have a diameter greater than the saucepan so that it will fit on the top without touching the simmering water.
   - Boil some water in a kettle and pour some into the bottom of the saucepan. SEE SAFETY NOTICE ABOVE.
   - Place the bowl on top of the saucepan and stir the mixture gently. Be careful not to touch the sides of the saucepan, as they will be very hot.
   - Stop when the mixture gets thick. (If it is too thick, then add some more boiling water from the kettle).
   - At this point you've made mortar. Stir the gravel into the mixture to turn it into concrete.
   - Leave it to cool before shaping it into two piers and two thin rectangular beams. Curve one beam into a semi-circular arch.
   - Put all the shapes onto a baking tray and place in the oven at 135°C until the objects dry.



Top Tips

- The saucepan can be placed on a heat proof mat on the table to allow the children to stir more safely.
- Make sure that you leave the concrete to completely dry out before testing the strength. This can take a few days.

Evaluate learning

- Once the pieces have dried, the children can use them to make a beam bridge with the piers and straight beam.
- Encourage the children to evaluate the strength of their bridges by gradually adding some weight to both structures.
  - Which cracks first under pressure?
  - Is the concrete waterproof? Try putting one of the piers in water to see what happens.
- Ask the children to find out who invented concrete and how it differed from the concrete of today. What are the advantages and disadvantages of concrete?
- Extend the task by challenging the children to conduct a fair test to investigate how different amounts of ingredients affect the strength. What impact does leaving out the gravel have?
- Children could also invent their own material. What special properties would it have? Do they know that scientists have invented self-healing concrete that can fix its own cracks? https://www.theguardian.com/sustainable-business/2015/jun/29/the-self-healing-concrete-that-can-fix-its-own-cracks

tiny tinkering tasks

Task title

Build a push button switch

(to use in Morse Machine)

Learning outcomes

• To understand that a switch is a piece of equipment that can connect wires to allow electricity to flow through a circuit.

• To build a push button switch to incorporate into a circuit.

EHoM link

SYSTEMS THINKING

To construct an object or tool requiring the successful interaction between components and subsystems.

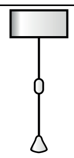
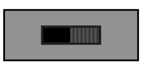
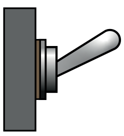
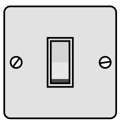
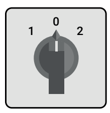
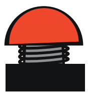
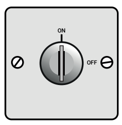
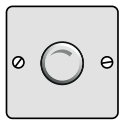
EDP link

CREATE

Key Stage/Year Group KS2 – Year 4/6

Resources required

• A collection of different switches (or pictures of switches):

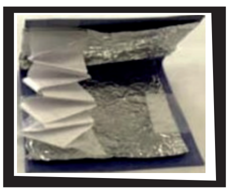
							
Pull switch	Slide switch	Toggle switch	Paddle switch	Selector switch	Push button switch	Key switch	Dimmer switch

It is recommended that each child makes a switch

• A4 cardboard – 1 sheet will make 4 switches

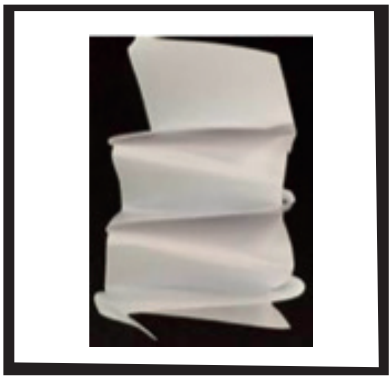
• Paper – a sheet of A4 should be plenty for at least 5 strips – recycled paper is fine.

• Foil – see photo



How to run the task

1. Engage the children in discussing where they have encountered switches in their daily lives. Can they locate any in the classroom? Ask them to make a note of all the different examples they can see. From this elicit what they know about switches - what job do they do? What would life be without them?
2. Show the children a collection of switches (photos or actual physical examples) and explain the different ways in which they close a circuit. Do they recognise any of the examples shown? Which kind of switches are used most in the classroom? To support the explain of switches in circuits you could use: https://www.bbc.co.uk/bitesize/topics/zq99q6f/articles/zt8vg82
3. Encourage children to work in pairs to explore switches for themselves. Give each pair a piece of A5 card and ask them to measure and cut out two 5cm x 10cm rectangles, then fold these rectangles in half.
4. Next, they should attach a piece of foil to the inside top half of the rectangle and a similar sized piece to the bottom half. They should make sure that the pieces of foil are slightly smaller than the half rectangles and do not overlap each other. Ask the children why this is important.
5. They should then build a paper spring by cutting a 2cm strip from a piece of A4 paper. Fold it in half and then back and forth over itself until it forms a small stack.
6. Finally, attach the spring to each side of the inside of the switch – cover as little of the foil as possible. Foil will conduct electricity. Tape will not! Your switch is now ready to become part of a circuit.



Top Tips

- Depending on the children and time available, you could pre-cut the cardboard and paper strips.
- Extend the task by challenging the children to create different types of switches – toggle switch, slide switch, push button switch – using different components. Which is the most effective in a circuit? This is a very useful and free resource which can be downloaded from the Design & Technology association: https://www.data.org.uk/resource-shop/developing-handmade-switches/

Evaluate learning

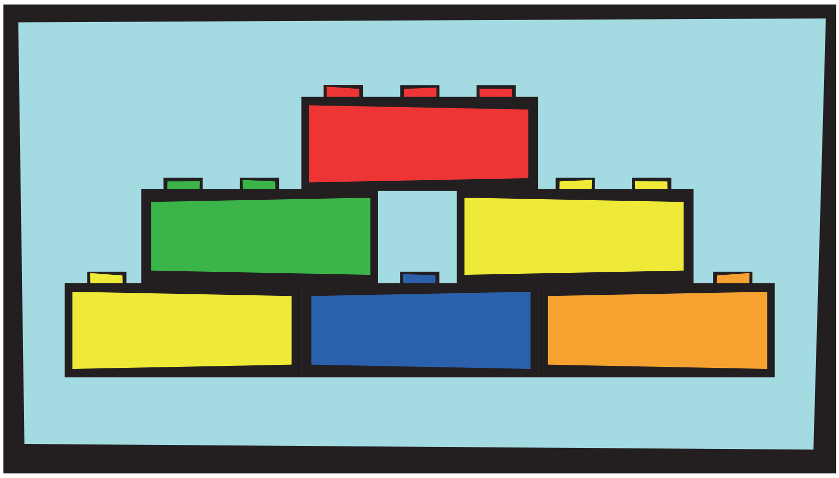
- In pairs explain the difference switches make to our lives.
- Which of your switches worked? Why, or why not?
- What is the purpose of the paper spring?
- How could you improve your switch?
- Have you an idea for a different type of switch? What is it?

Home

tiny tinkering tasks

Task theme

Visualising and Lego building



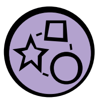
Task title

Can You ‘Sneak A Peek’?

Learning outcomes

- To build an accurate copy of a Lego model by memorising the example.
- To communicate ideas effectively.
- To work as a team.

EHoM link



SYSTEMS THINKING
Identify a product’s systems, subsystems and components and how they interact.

VISUALISING
Convey ideas accurately to others through verbal communication.

EDP link

Key Stage/Year Group Any key stage or year group depending on the complexity of the model.

Resources required

- Enough Lego bricks to build a small structure.
- A bag of identical Lego bricks for each group to replicate the structure.

How to run the task

THIS IS A SKILL DEVELOPMENT TASK

1. Engage the children in playing with Lego or similar construction blocks. Whilst they're engaged you should build a small structure and keep it hidden from them.
2. Explore model making by playing this 'sneak a peek' task. Divide children into small groups (3 or 4) and give each group a bag of identical Lego bricks.
3. Tell the children that they will be taking turns to be peekers and makers – they should decide on who the first person will be to 'take a peek' at the hidden design.
4. Start the clock and ask the first person to come up to see your model. Each team should send one person so they can look at the model at the same time (up to 30 seconds). They need to memorise as much as possible.
5. After this time, they return to their team and have one minute to verbally instruct their teams as to how to build a replica – the peeker must not handle any of the bricks.
6. Repeat with a new peeker from the team and continue until they've all had a go, or one of the teams successfully duplicates the original structure – or time runs out.

Top Tips

- Try creating both a recognisable object (such as a house) and a random structure. Which proves easier to replicate? Why do pupils think this might be?

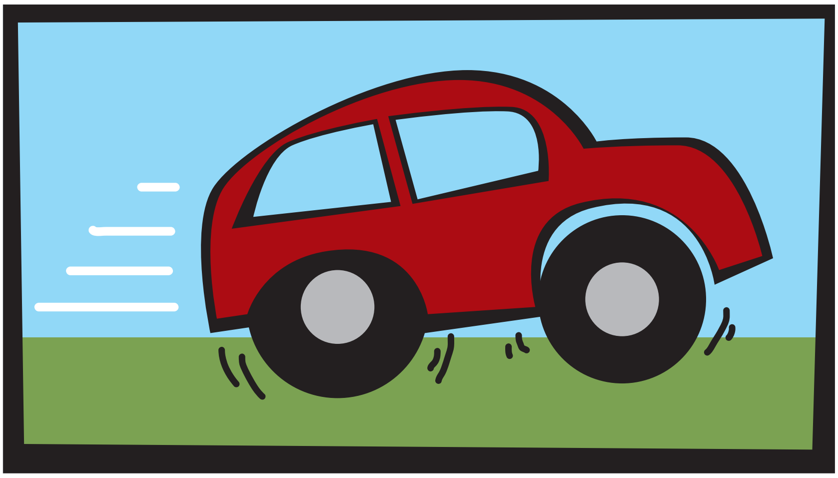
Evaluate learning

- What different strategies did the children use to memorise the sculpture? How did this help them?
- Were there different strategies between the groups?
- Why was the winning team successful?
- What would you do differently next time and why?

Home

tiny tinkering tasks

Task theme
Wheels in Motion



Task title
How do wheels reduce friction?

Learning outcomes

• To understand how the wheel and axle system simplifies the transportation of materials.

• To investigate and compare different sized wheels.

EHoM link

PROBLEM FINDING
Ask questions based on observations.

SYSTEMS THINKING
Identify how an object or tool breaks down into parts.

EDP link

Key Stage/Year Group KS1 – Year 2

Resources required

• Cardboard boxes
• Heavy objects to put inside the boxes
• A selection of toy vehicles with different sized wheels

How to run the task

1. Engage the children by asking them to put heavy objects inside the cardboard boxes and then try to move them along the ground by pushing or pulling the box. Discuss the problems. If appropriate, introduce the terms 'friction' and 'gravity' as forces which are impeding the progress.
2. Elicit their understanding by encouraging them to discuss the problems they have found and explain why the problem may exist. When appropriate, explain the terms 'friction' and 'gravity' forces which are slowing down the movement of the box.
   DEFINITION: Friction is a force between two surfaces that are sliding, or trying to slide, across each other. For example, when you try to push a box along the floor, friction makes this difficult.
   Gravity is a force which tries to pull two objects toward each other. The Earth's gravity is what keeps you on the ground and causes objects to fall.
3. Provide the children with a series of different toy vehicles to explore – if they can take them apart all the better. What helps these toys to move easily? Ask the children how they could adapt their cardboard box to make it move more easily?
4. Explain the different system components (wheel and axle) and discuss with the children what jobs they do.
   DEFINITION: Wheels are simple machines that reduce the force of friction. A wheel allows an object to roll along the ground.
   Axles – an axle is a rod which passes through the centre of a wheel to enable the wheels to rotate.
5. Focus the children's attention on the key features of the toys and their wheels. Does the size of the wheels make a difference to the performance of the vehicle? Using these ideas encourage the children to draw and label a sketch of their ideas. Make sure the wheels in the drawings are mounted on axles.
6. Ask the children to evaluate each other's designs. Can they make any improvements following their investigation?

Top Tips

- For homework, ask the children to research the history of the wheel and how it has evolved since it was first invented.
- In a separate session, challenge the children to build and try out their vehicle designs.

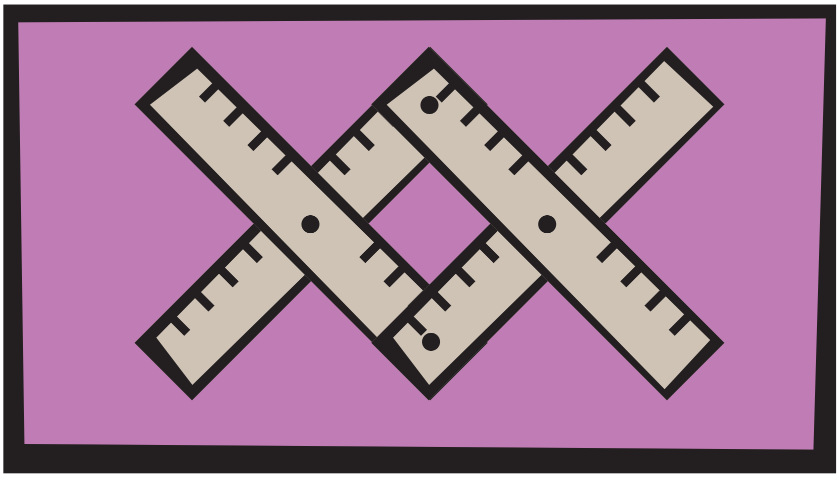
Evaluate learning

- How did people move heavy objects before wheels were invented?
- Why do we need an axle to make our wheels turn?
- Are smaller wheels or larger wheels better for moving heavy loads? Why?

tiny tinkering tasks

Task theme

Playing with Pantographs



Task title

How can levers change the size of drawings?

Learning outcomes

- To make a machine that enlarges drawings.
- To understand how a pantograph works.

EHoM link

SYSTEMS THINKING
To construct an object or tool requiring the successful interaction between components and subsystems.

IMPROVING
To make objective judgements against success criteria and constraints. Explore specific points of failure for ways in which to improve object or tool acknowledging possible trade off within constraints.

EDP link

CREATE

IMPROVE

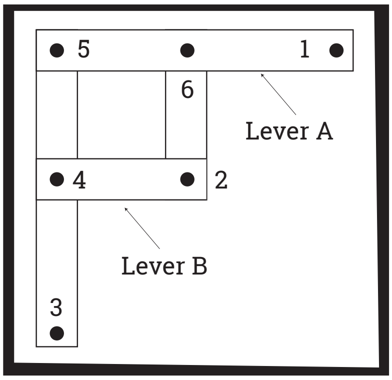
Key Stage/Year Group UKS2 – Years 5 & 6

Resources required

- Recycled, thick cardboard (e.g. a delivery box)
- 4 x paper fasteners per pantograph
- Scissors
- 1 x metre ruler and 1 x 30cm ruler
- 2 felt tips
- Nail
- Blank paper for drawing on
- Blu tack

How to run the task

1. Engage the children in the preparation of the task. Using a piece of thick cardboard encourage them to measure and cut: two strips measuring 5cm x 45cm; two smaller strips measuring 5cm x 25cm and one large cardboard square measuring 60cm x 60cm. NB: You could reduce these sizes proportionally if your cardboard is smaller.
2. Support the children by making a hole with the nail at both ends of all the strips of cardboard (about 1 cm from each end).
3. Ask the children to fix the cardboard strips together, using paper fasteners, at points 4, 5 and 6. Provide them with a diagram of the layout.
   Support the children by making a hole with the nail at position 3. The children will then be able to secure the frame to the cardboard square at this position using the remaining paper fastener.
4. Place your felt tips through the holes at positions 1 and 2. Keep the lids on for now.
5. Slide a piece of paper underneath the cardboard strips and felt tips and fix to the cardboard square with Blu tack or drawing pins.
6. Take the lids off your pens and hold the pen at position 2. Draw a square. Compare the size of the square drawn by both pens.
7. Explore whether a reduced-scale drawing can be made by using the pen at position 1 to create the original drawing. Make an additional hole between 5 and 6 and place your pen there. Draw a shape and compare the two outputs.
8. Extend – challenge the children to experiment further by altering the position of the connected pieces. What happens if you move connection 6 nearer or further away from connection 5?



Top Tips

- You may wish to push your pens/pencils through a small section of rubber before inserting them through the cardboard. This will help to keep them stable.
- To raise the pantograph slightly – again to facilitate drawing – put an additional strip of cardboard under position 3. You may need a longer split pin to fasten these together.

Evaluate learning

- Is there anywhere else you could place the pen?
- Does changing the position of the connecting piece affect the result?
- Is there anything you could do to improve the quality of your output?
- Can you construct a drawing machine that draws different sized circles?
- Who invented the Pantograph?
- How did the very first typewriters work?

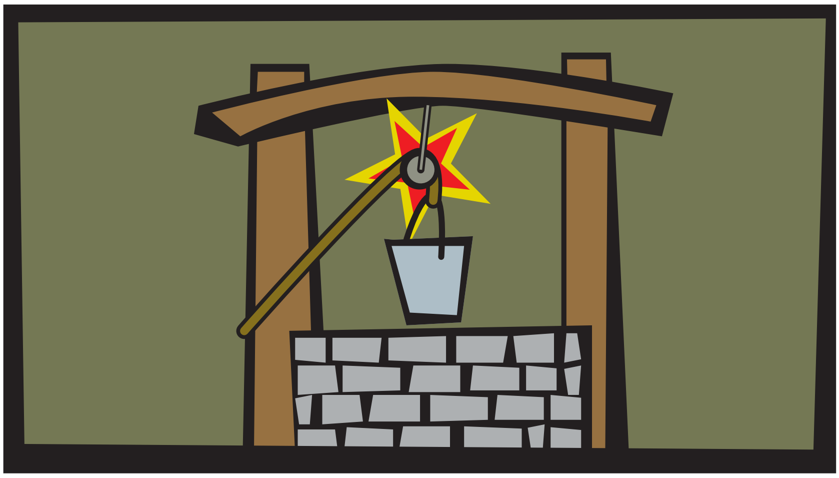
What is a PANTOGRAPH and how does it WORK?

A Pantograph is a compound machine consisting of several levers. The length of the lever and the position of its fulcrum (the point about which it rotates) affects the distance that the end of the lever moves. Pen 1, which is attached to Lever A is further away from its fulcrum than Pen 2, attached to Lever B, so it moves a greater distance and therefore creates a larger image.

tiny tinkering tasks

Task theme

Pulleys



Task title

How does a fixed pulley make your work easier?

Learning outcomes

- To understand how a fixed pulley works and describe the different components.
- To use this knowledge to design a mechanism to raise a flag.

EHoM link

PROBLEM FINDING
Ask questions based on observations.

SYSTEMS THINKING
Create an object or tool from joined parts.
Give thought to how parts join.

EDP link

ASK

CREATE

Key Stage/Year Group KS1 – Year 2.

Resources required

FOR EACH GROUP:

- 1 x empty spool
- 1 x Dowel rod
- 1-pint plastic milk carton with handle (if empty fill with water)
- String

FOR FLAGPOLE:

- Flag – paper, coloured crayons, Sellotape
- 2 x spools
- Skewer / piece of dowel
- Cardboard box lid / piece of Styrofoam to fix flagpole in
- String

How to run the task

1. Engage the children by asking them to lift the milk carton off the ground with their hands. How heavy does it feel?
2. Show the children a picture of a well, which has a fixed pulley. Elicit their understanding by asking them how the water is fetched from the bottom. What simple machine can they see in the picture? How is it constructed?
3. Provide the children with the dowel, empty spool and string to explore making their own pulley systems to lift the milk carton. Ask the children if it is easier to lift the milk carton with their pulley. Can they explain why? What is the difference between lifting it this way? (Because with the pulley you are pulling down in the same direction as gravity, whereas by the first method you are pulling up against gravity).
   DEFINITION: A pulley is a simple machine that consists of a wheel with a groove in that holds a cord. A fixed pulley stays in place; the pulley turns as the cord moves over the wheel, and a load is raised as the cord is pulled.
4. Challenge the children to extend their knowledge to design and create a pulley to raise a flag. Design the flag and use the equipment to create their pulley system.
   - Stick the pointed end of the skewer into the foam making sure that it is secure.
   - Hot glue a spool near the top of the skewer and another spool near the bottom, leaving a little space above the foam.
   - Tie a piece of string tightly around both spools, making a long loop. Trim the ends.
   - Make your flag and attach it to one side of the string.
   - Pull on the string to raise and lower the flag.
5. Encourage the children to evaluate each other's designs. Can they gain the same effect with one spool? Which works better?

Top Tips

- https://www.youtube.com/watch?v=9T7tGosXM58 – although quite old, this is still quite an engaging video about pulleys by Bill Nye.

Evaluate learning

- Ask the children to observe the distance the string is pulled down and the distance and the direction in which the flag moves. (The distance is the same but the flag moves in the opposite direction)
- Would the size of the spool affect the results?

tiny tinkering tasks

Task theme
Mastering Morse

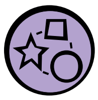
A •–	J •–––	S •••
B –•••	K –•–	T –
C –•–•	L •–••	U ••–
D –••	M ––	V •••–
E •	N –•	W •––
F ••–•	O –––	X –••–
G ––•	P •––•	Y –•––
H ••••	Q ––•–	Z ––••
I ••	R •–•	

Task title
How can you use light to send messages?

Learning outcomes
- To design and build a Morse Code transmitter which uses light to send signals.

EHoM link

SYSTEMS THINKING
To construct an object or tool requiring the successful interaction between components and subsystems.



APAPTING
To embrace an iterative approach alternating between plan (doesn't have to be written) and create.

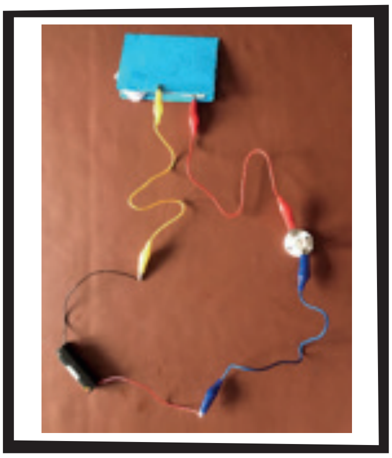
EDP link

Key Stage/Year Group UKS2 – Year 6

Resources required
It is suggested that for this activity, children work in groups of 3 or 4. The resources listed below are per group:
- 1 x AA (1.5V) cell
- 1 x Battery holder
- 1.5V bulb and bulb holder
- 3 x Crocodile leads
- Push button switch (made in previous activity)
- Morse code key – copy and enlarge above image

How to run the task

1. Engage the children in getting the bulb to light using the circuit components provided. This will be a good assessment of previous learning in Year 4 and will elicit their knowledge.
2. Support if necessary, by giving the following instructions for constructing the circuit:
   - Use the first crocodile lead to connect one side of the bulb holder to the positive wire of the battery holder.
   - Connect the second crocodile lead to the foil on one half of the switch. Make sure that the metal of the crocodile clip is firmly connected to the foil.
   - Connect the remaining end to the other side of the bulb holder.
   - Connect the third crocodile lead to the foil on the opposite side of the switch and the other end to the negative wire of the battery. The circuit is now complete.



3. Press down on the switch. The bulb should light up. If not check the wiring and that the bulb is functioning.
4. Explain that in the Morse Code table you have given them, the symbols are called "dots" and "dashes". For example, the code to send the letter "A" is "dot dash." The dots are the short signals, and the dashes are long signals. So, to send the letter "A", you would send a short flash of light followed by a long flash of light.
5. Encourage the children to explore their Morse Code machine by using the push button switch to create short and long flashes. These imitate the Morse Code messages sent during war times. Ask them to try sending "SOS." As the table shows, SOS is three short flashes, then three long flashes, then three short flashes.
6. Ask the children to elaborate by sending different letters to their group to see if they understand. The same circuit can be used to send a signal back to indicate whether they understood the letter you sent:
   - One flash back from them means "I understood what you sent"
   - Two flashes: "send that letter again"
7. Using this learning, extend the task by challenging the children to send a whole word successfully? How about a whole sentence?
8. Can their friends work out what has been sent and generate a reply?

Top Tips

- Support: have a prepared, working circuit available for children who are struggling.
- Elaborate: try replacing the crocodile leads with different materials such as strips of foil, binder clips or metal buttons.
- To create a brighter effect, use 2 x 1.5V cells and a 2.2V bulb (readily available from TTS).
- Download the App 'Morse-it' on to iPads for children to see Morse code in action: https://apps.apple.com/gb/app/morse-it/id284942940

Evaluate learning

- If you change the order of the components in this circuit, will the bulb still light?
- Is there anything that you must keep the same?
- Can you send a whole word successfully to your partner?
- Is it possible to distinguish between a short and long flash of light?
- Would using a buzzer be easier? Why do you think this?

tiny tinkering tasks

Task theme
Roman Engineering

Task title
How did the Romans make their roads so straight?

Learning outcomes
• To investigate the impact that the Romans had on Britain.
• To understand the tools Roman engineers used to create straight roads.
• To design and make a Roman groma.

EHoM link

PROBLEM FINDING
Ask pertinent questions to better understand design problems, success criteria and constraints.

CREATIVE PROBLEM SOLVING
Generate and evaluate multiple ideas to help choose optimal solution. Have good people skills to generate ideas collectively.

SYSTEMS THINKING
Construct an object or tool requiring the successful interaction between components and subsystems.

EDP link
ASK
IMAGINE & PLAN
CREATE

Key Stage/Year Group LKS2 – particularly Year 4

Resources required

It is suggested that children work in pairs and make one groma between them. However, if resources are an issue then it is perfectly possible to work in larger groups.

For each groma you will need the following equipment:

• A dowel rod 60cm – 1m in length
• An A4 piece of grey board, thick cardboard, or 4 large wooden craft sticks
• Glue – either PVA or glue gun
• Paper fasteners
• String
• Objects to add weight: paperclips, Blu Tack, washers etc.

Other equipment

• Heavy duty one-hole punch – to be used by the teacher https://www.amazon.co.uk/gp/product/B07NQFSKP6/ref=ppx_yo_dt_b_asin_title_o05_s00?ie=UTF8&psc=1
• Sketch books
• Extra poles for testing – you could potentially use metre rulers for this.

How to run the task

1. Engage the children by asking them what feats of engineering the Romans were famous for. Collect ideas on Post-It notes or on a whiteboard and display suggestions. Ideas the children may come up with are bridges, baths, underfloor heating and aqueducts. This task is focused specifically on road networks, so support them if they do not volunteer this idea themselves. Guide them in the right direction by clarifying that by engineering you mean things that the Romans built whilst they were in Britain.
2. Stimulate their thinking by showing a map of the Roman roads in Britain: https://simple.wikipedia.org/wiki/Roman_roads_in_Britain#/media/File:Roman_Roads_in_Britannia.svg and use questioning and some discussion to elicit what they already know about Roman roads. This may vary greatly.
3. If you think it useful you could set a pre-task before the lesson as homework so that the children explore the topic by carrying out some secondary source research.
   There are plenty of useful sites on the Internet to use as reference material - http://www.primaryhomeworkhelp.co.uk/romans/roads.htm
   http://www.photographers-resource.co.uk/A_heritage/Roman/Roman%20roads.htm
   Another idea is to give the children atlases and ask them to find the roads using the following table:

Mapping Roman Roads

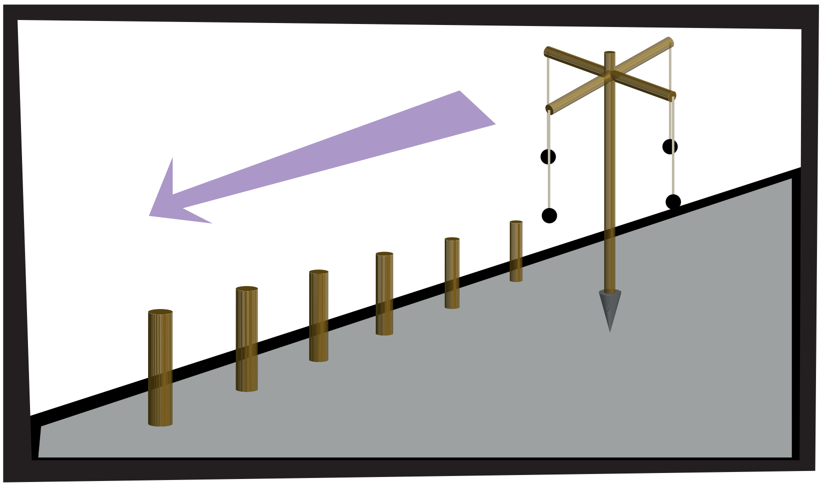
Name of road	Location
The Fosse Way	Exeter to Lincoln
Stane Street	Chichester to London
Dere Street	York to Scotland
Ermine Street	London to York (via Lincoln)
Akeman Street	St Albans to Cirencester
Watling Street	Richborough to Wroxeter

4. Explain that the challenge is to make their own version of an instrument that Roman surveyors used to help keep their roads straight – a wooden cross with weights hanging from it, known as a 'groma'. There is a BBC explanation of gromas and how they work by Adam Hart Davis at: http://www.bbc.co.uk/history/ancient/romans/tech_01.shtml#two
5. Using the resources suggested above, task the children to design and sketch their own groma. Note they should be paying particular attention to how the different elements join together and how they will weigh down their pieces of string. Encourage the children to think-pair and share their ideas.

6. Depending on your preference, now challenge the children to create their designs – you may choose to do this in pairs or small groups. The children should decide how they are going to fix the different components together. Help may be needed to punch holes or apply hot glue. Provide enough time for the children to make and improve their groma. They should consider how to attach the string effectively and investigate the best objects to use to weigh down the string.

TESTING THE GROMAS

7. Once the children have completed their gromas, you can take them outside onto the school field to test. Children should do this in groups of 4 using one of their gromas.
8. One child should choose a point on the field and holding the groma, close one eye and line up the opposite two strings with the central rod. They should then focus on a point in the distance and instruct a member of their group to walk 20 paces with a pole, making sure that the pole lines up with the groma. Once the pole is perfectly lined up, it can be pushed into the ground. This process should then be repeated several times with additional poles until up to 5 posts have been placed and planted.

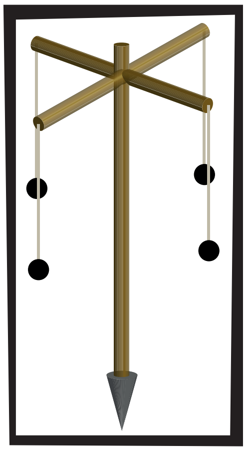


9. To check the accuracy of the posts, take the groma to the end of the line and look down the line. Adjust if necessary.

Top Tips

SUPPORT – to help children with their designs provide them with a diagram of what a groma should look like. They can then choose suitable materials from the available resources.

- Have an example already made for children to refer to if necessary.
- Advise the children that each piece of string should be the same length and have the same amount of weight attached.



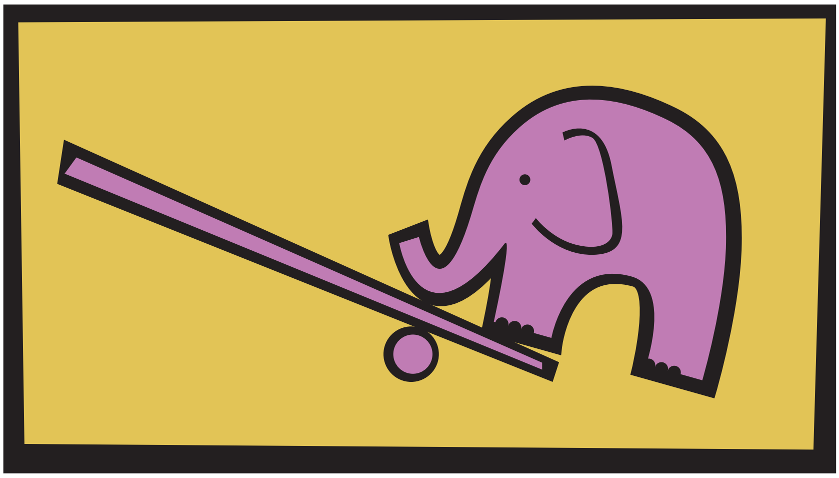
Evaluate learning

- How could the groma be improved? What would the impact be of changing the length of the string? Could different materials be used instead of string?
- Which weights worked best?
- Is there a relationship between the number of paperclips and the length of string?
- What would happen to the accuracy of the equipment if it was very windy? How could you counteract this?

tiny tinkering tasks

Task theme

Levers



Task title

How are very heavy loads lifted?

Learning outcomes

- To understand how simple machines such as levers make work easier.
- To identify how the lever is used in many familiar household products.
- To discover a relationship between the length of lever and the amount of lift.

EHoM link

PROBLEM FINDING
Ask questions based on observations.

SYSTEMS THINKING
Illustrate (e.g. through labelling) how an object or tool breaks down into parts.

EDP link

ASK

IMAGINE & PLAN

Key Stage/Year Group Suitable for both KS1 and LKS2

Resources required

- A selection of screwdrivers, pennies
- A selection of lever lid tins – these can be bought online – or old paint / syrup tins could be used.
- Pencils and books

How to run the task

1. Engage the children in exploring. Hand each group a lever lid tin, a screwdriver and a collection of coins. Before discussing the equipment, challenge them to open the lid with the coins and then the screwdriver. Which was the easiest to do? Can they explain why?
2. Elicit the children's understanding by asking them to explain how the coins and the screwdriver are working to open the lid. Introduce and explain the term 'lever', developing ideas from the children's explanations: lever. DEFINITION: a lever is a rigid bar which pivots around a fixed point called a fulcrum – the longer the lever, the easier it is to lift the lid (load).
3. Extend the challenge by asking the children to lift a pile of books using two pencils – one as a lever and one as the fulcrum. (NB: you could also use a wooden ruler with a triangular prism from the shape box as the fulcrum)
4. Encourage the children to evaluate their learning by asking them to draw a diagram labelling the different parts of the lever system (load, fulcrum and effort). You could introduce the notion of 'audience' to elaborate on this task – e.g. Draw a labelled diagram that would be useful to explain levers and fulcrums to small children, your grandparents etc. Can the children think about where the different groups of people will encounter levers in their daily lives?

Top Tips

- You may want to encourage children to fix their fulcrum to the desk with Blu Tack to make it more stable.
- Watch clip about Archimedes for more information about levers https://www.youtube.com/watch?v=YlYEi0PgG1g
- Challenge - experiment with lever length to see how much weight you can lift. Is there a mathematical pattern? http://www.discovere.org/our-activities/single-activity-detail/Leave%20it%20to%20Levers

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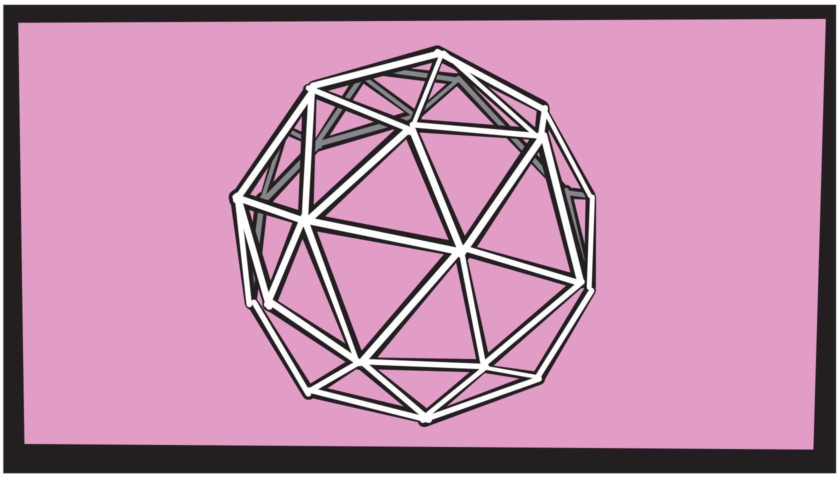
Evaluate learning

- Why might we want to use levers?
- Where can we find them?
- What advantage do they give us?
- Does the length of the lever affect the results?
- What happens when you move the fulcrum?

tiny tinkering tasks

Task theme

Structural Engineering Building a Geodesic Dome



Task title

Which shapes make the strongest structures?

Learning outcomes

- To explore the relationship between triangles and other 2D shapes.
- To understand why triangles are fundamental to the way we build our environments.
- To work as a team.

EHoM link

SYSTEMS THINKING

Construct an object or tool requiring the successful interaction between components and subsystems (SEERIH)

EDP link

CREATE

Key Stage/Year Group UKS2

Resources required

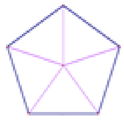
To make an 80cm diameter Geodesic Dome the following resources are required: -

NB: this will allow a class of 30 children to work together to complete one dome. Each child can make both a short and long tube with the teacher making the remaining 5 long tubes, possibly as part of a demonstration process.

- 65 sheets of A4 paper – ideally two colours should be used – 30 sheets for the short (A) tubes and 35 sheets for the longer (B) tubes.
- 15 x 6mm wooden dowel rods approximately 50 cm in length for children to roll the paper around.
- Sellotape – ideally with a dispenser for each pair of children.
- Heavy duty one-hole punch – to be used by the teacher https://www.amazon.co.uk/gp/product/B07NQFSKP6/ref=ppx_yo_dt_b_asin_title_o05_s00?ie=UTF8&psc=1
- Box of paper fasteners
- A protractor
- Felt tip or white board pen for each pair.
- Scissors

How to run the task

1. Engage the children by asking them to draw some regular pentagons using a ruler and a protractor and measuring interior angles of 108°. For guidance you could watch a video on YouTube such as: HTTPS://YOUTU.BE/NNGCJCBOK-G
2. Elicit their understanding by revisiting the properties of regular pentagons (5 equal sides and angles – derived from the Greek πέντε pente and γωνία gonia, meaning five and angle) Ask the children to check their partner's pentagons to see if they meet these criteria by measuring the sides.
3. Explore the pentagon further by asking the children to choose one of their pentagons and split it into triangles. How many triangles are they made up of? What kind of triangles are they?



4. Explain that they are now going to work as a team to create their own sets of pentagons which they will then join together to make a dome shape.

MAKING THE PENTAGONS

5. Elaborate – the children will now use knowledge of the structure of pentagons to make a 3D model. First give each child two pieces of A4 paper (one of each colour) and a wooden dowel rod. Demonstrate how to roll the paper tightly around the rod to create a tube. This should be done diagonally to maximise the length created.
   Positioning the rod across the diagonal and then moving back to the corner before rolling will generate the smoothest tube. This can be done in pairs with one child rolling the paper and the other sticking a piece of Sellotape around the centre of the paper tube to secure.

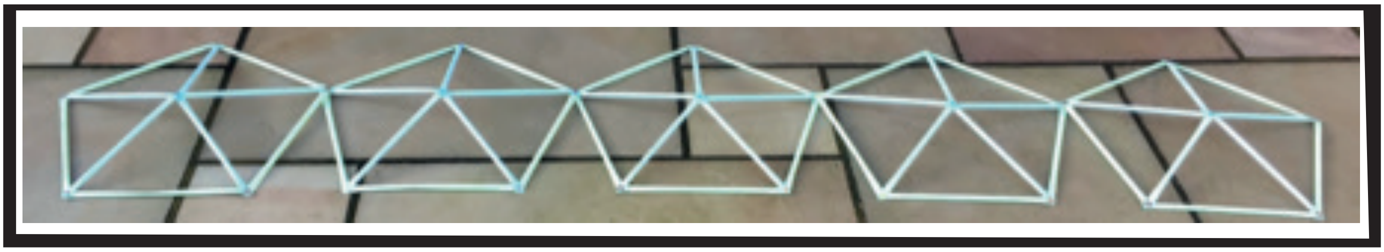
6. Decide which colour is going to be A (short) and B (long). Ask the children to find the middle of the strip (approximately) and draw a small pencil mark for reference. They should then use a ruler to measure 11cm either side of the mark, placing a dot with the felt tip. This will create an overall distance of 22cm and ensure that the tube is equally strong at both ends.
7. Do the same with strip B, this time measuring 12.5cm from the centre. This will create an overall distance of 25cm.
8. Instruct the children to carefully wind some Sellotape around each dot to strengthen the paper. Using the dots as a guide, a hole should be made with the punch at both ends of all the pieces of paper. This could be done by the teacher.
9. Once the holes have been punched the children can trim the ends of tubes making sure that they leave about 0.5cm of paper past the holes; otherwise the structure is likely to tear.

10. To assemble the pentagons themselves you will need 5 short (A) tubes joined at the centre and 5 long (B) tubes around the perimeter. The children will need to work in groups of 5 combining their pieces. Care should be taken when placing the paper fasteners through the holes. The children should be encouraged to maintain consistency by joining the tubes together in the same order – i.e. keeping the short tubes on top. You should end up with 6 pentagons, which are all identical in shape. You can check this by placing them on top of each other.

EXTEND - CONSTRUCTING THE GEODESIC DOME

Once the pentagons have been completed, the dome can be constructed. This will need adult help as it can be quite fiddly.

11. Ask a representative from each group to bring out their pentagon to the front of the class. You will need enough space to be able to lay all the pentagons out in a line.
12. Arrange five of the pentagons in a line, as shown, making sure that the bottom of the pentagons forms a straight line.



13. Join these pentagons together by taking out and reinserting the adjoining split pins. This will form the wall of the dome.
14. Form the 5 joined pentagons into a circular shape and attach the sixth pentagon to the top to make the 'roof'.
15. Finally, use the remaining 5 long (B) tubes to link the base of the pentagon wall together in a continuous 'ring' creating a stable base for the now completed Geodesic Dome.

Top Tips

A 1 metre diameter Geodesic Dome is formed of 6 pentagon shapes joined together, with each pentagon constructed from:

• 5 short (A) tubes joined in the centre
• 5 long (B) tubes around the perimeter of the pentagon

To make the final dome a further 5 long (B) tubes are needed to link the base of the dome together, bringing the total number of tubes to 65.

• 30 short (A) tubes
• 35 long (B) tubes

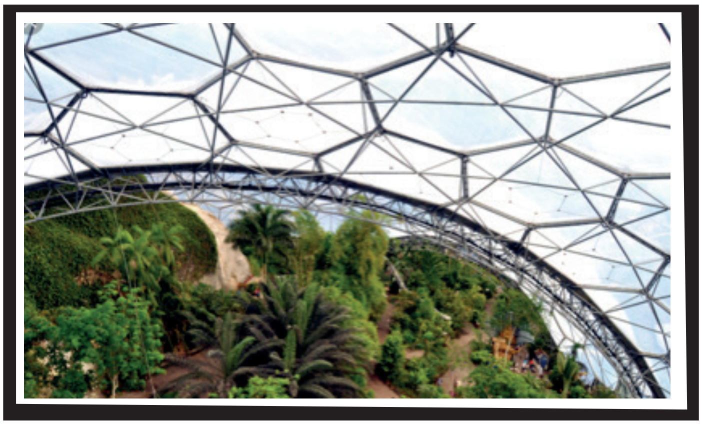
For an 80cm diameter dome: (A) tube = 22cm and (B) tube = 25cm - this size is probably more manageable for the children and fits within the 30cm ruler

For a 1 metre diameter dome: (A) tube = 27cm and (B) tube = 31cm

In simple terms the length of A is 88% the length of B (rounded). To make a smaller or larger dome, just apply this ratio to your different lengths. The diameter of the finished dome will be approximately 3.7 times the length of A.

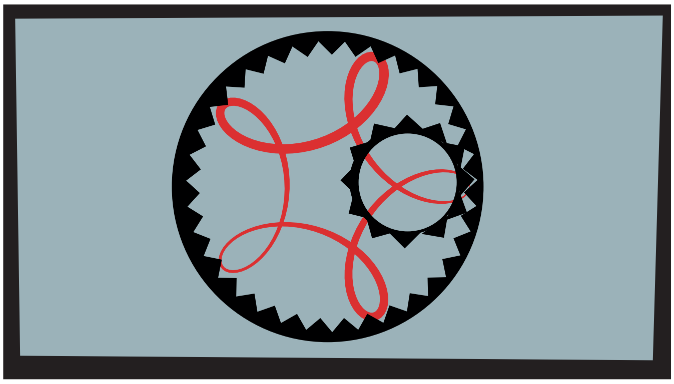
Evaluate learning

- Once the dome has been successfully constructed, as the children to take a closer look and see if how many different 2D shapes they can identify – they should be able to see triangles, hexagons and pentagons. Are all the triangles the same? Are the hexagons regular?
- Why do you think that triangles are such a strong shape? They are very rigid and cannot be easily deformed when subjected to force: https://www.youtube.com/watch?v=AoS0UvVfxRQ
- Can you think of any uses for your geodesic dome? What other materials could you make it out of? How could you make it waterproof? Show pictures of biodomes at the Eden Project.



tiny tinkering tasks

Task theme
Gears

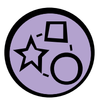


Task title
How does a spirograph work?

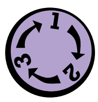
Learning outcomes

- To understand how simple machines such as gears make work easier.
- To identify how gears are used in many familiar products.
- To discover a relationship between the different sizes of gear and the turning force.

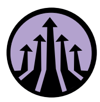
EHoM link



SYSTEMS THINKING
Create an object or tool requiring the successful interaction between components and subsystems.



ADAPTING
Embrace an iterative approach alternating between plan and create.



IMPROVING
Make objective judgements against success criteria and constraints. Explore specific points of failure for ways in which to improve object or tool acknowledging possible trade off within constraints.

EDP link

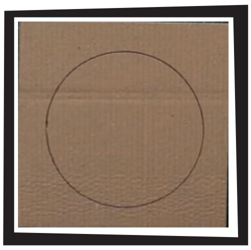
Key Stage/Year Group LKS2 (Years 3 and 4)

Resources required

- A selection of objects/photos of objects that contain gears: rotary whisk (you may be able to get hold of one of these), bicycle, car, washing machine, mechanical clock, hand drill, manual tin opener, hand crank pencil sharpener, electric food mixer.
- Corrugated Cardboard – you will need a number of large boxes.
- Scissors
- Glue guns or PVA
- Felt tip pens

How to run the task

1. Engage the children by asking them what they already know about gears. Do they know of any machines that contain gears? (They will probably name bicycles and cars) Show them some pictures of more unusual objects such as a rotary whisk. Do they know how gears help in this piece of equipment?
2. Explain what gears are and how they can make our lives easier
   DEFINITION: gears are basically wheels with teeth around the outer rim. When they are used in a gear system, they can make things easier to move. The teeth on the two gears fit together allowing one gear to turn the other. In a simple two gear system, when you rotate one of the gears clockwise, the other gear will rotate in the opposite direction. As well as being able to change the direction of rotation, gears can also change the rate of rotation.
3. Show the children some patterns drawn by a spirograph. Tell the children that different gears have created this design. Allow the children to explore gears by following these steps to make their own version of a spirograph:
   - Place a paper plate on top of a square of corrugated cardboard and draw around the edge. Make sure there is at least 2 cm of cardboard left as a frame.
   - Cut out the circle with sharp scissors (children may need help with this).
   - Repeat and stick the two pieces of cardboard together firmly. This can be done with PVA or a glue gun.
   - Peel the paper off a small strip of corrugated card (about 1cm wide) to reveal the corrugations. Stick this to the inside of the circle so that the corrugations are facing inwards. This is best done with a glue gun. Adult help may therefore be required for this part.
   - Cut out a small circle from the spare card and cover the outer edge with another strip of corrugated card so that the corrugations are on the outside. Again, a glue gun is the best way of fixing this.
   - Make two holes with a sharp implement anywhere on the circle. Different positions will give you different patterns.
   - Test your spirograph by inserting a coloured pencil in one of the holes and drawing on a sheet of white paper.
   - Extend the task by challenging the children to create different sized gears to draw with.
   - Encourage the children to evaluate their patterns. Can they improve the quality by changing the height of the corrugated card?



Top Tips

- You may wish to prepare two gears on a piece of cardboard to show the children how they turn in opposite directions. Or this gif : https://bournetoinvent.com/projects/9-SC-Mechanisms/pages/5_Lesson.html is useful to show rotating gears.

Evaluate learning

- How do the corrugations help you make the pattern?
- Would it work with smooth surfaces? Why not?
- What patterns do you get if you put your hole in the centre of the circle?
- What different patterns can you make with larger and smaller circles?
- Can you predict what the pattern will be?