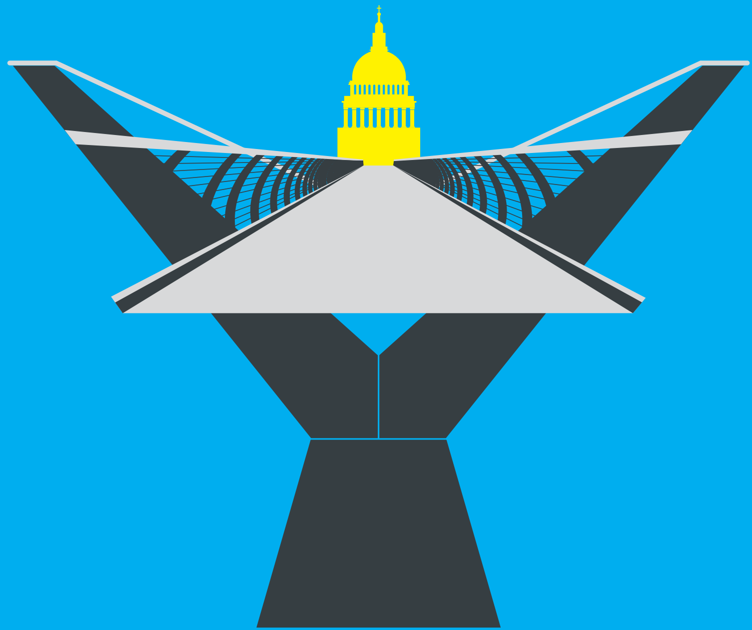
MAYOR OF LONDON

THE LONDON CURRICULUM

DESIGN & TECHNOLOGY KEY STAGE 3

BRIDGING THE RIVER



UCL Institute of Education

THE LONDON CURRICULUM

PLACING LONDON AT THE HEART OF LEARNING

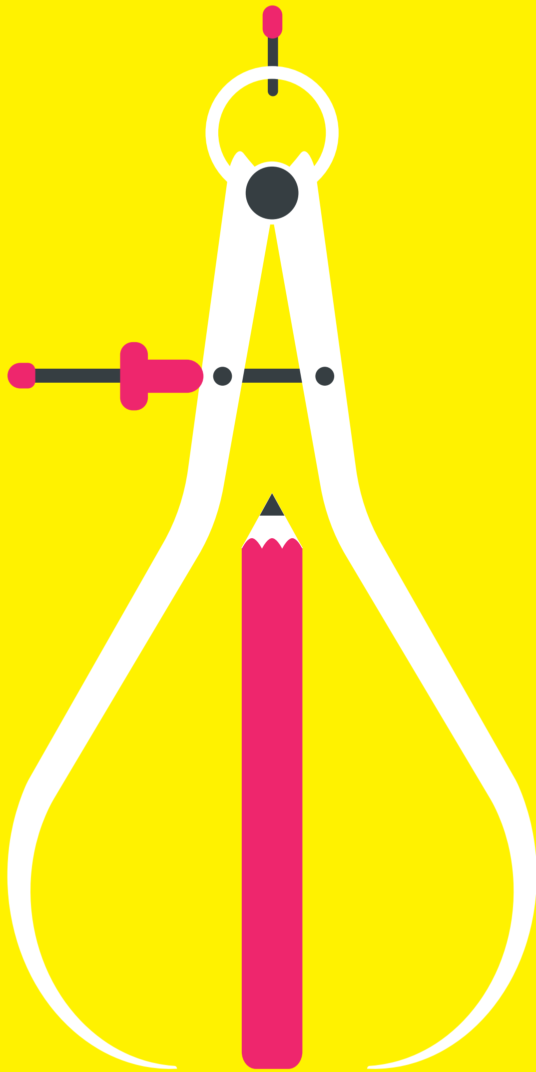
The capital is the home of innovations, events, institutions and great works that have extended the scope of every subject on the school curriculum. London lends itself to learning unlike anywhere else in the world. The London Curriculum aims to bring the national curriculum to life inspired by the city, its people, places and heritage.

To find out about the full range of free resources and events available to London secondary schools at key stage 3 please go to www.london.gov.uk/london-curriculum.

STEM in the London Curriculum

London provides numerous historical and contemporary cutting edge examples of scientists, engineers and mathematicians who have worked in their fields to create innovative solutions to problems throughout the world. Population growth, trade, communication, transport, health, food, water supply and many other aspects of life in London have driven technology-based innovations London Curriculum science, maths, design & technology teaching resources aim to support teachers in helping their students to:

- **DISCOVER** the application of their subject knowledge to the life of the city.
- **EXPLORE** their neighbourhood and key sites around London, learning outside the classroom to see and understand how STEM subjects have shaped many aspects of the city.
- **CONNECT** their learning inside and outside the classroom, analysing situations and using their subject knowledge to create and present solutions.



CONTENTS

BRIDGING THE RIVER OVERVIEW

THREE LONDON BRIDGES
© Kois Maih

UNIT AIMS AND OBJECTIVES

London's bridges are a rich subject for the study of design and technology. They are elegant landmarks that exemplify the best technology of their time and relate closely to the city's social and economic development. London exists because of the River Thames, however, the river also divides the city, and for many centuries London designers and engineers have sought to find new ways to bridge the Thames and bear the load of the capital's busy traffic, while not obstructing the river's flow or its many passenger and cargo boats. In the process they have created some of the London's most iconic sights. In this unit students will engage with one of the most basic and long-standing engineering challenges tackled by Londoners throughout time. They will explore, test and use the properties of materials and the performance of structural elements to inform bridge design. A research visit to the River Thames will offer an opportunity to explore the technology and history of some of the most famous bridges in the world. And as a final project, students will plan an exhibition to share the design features and stories of the Thames' bridges with a younger audience.

KEY STAGE 3 NATIONAL CURRICULUM

This unit addresses specific requirements of the key stage 3 national curriculum for design & technology. Through a variety of creative and practical activities, pupils will be taught the knowledge, understanding and skills needed to engage in an iterative process of designing and making. Students will:

Design

- use research and exploration to identify and understand user needs
- identify and solve their own design problems
- select from and use materials, components and ingredients, taking into account their properties

Evaluate

- analyse the work of past and present professionals and others to develop and broaden their understanding
- test, evaluate and refine their ideas and products against a specification, taking into account the views of intended users and other interested groups
- understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists

Technical knowledge

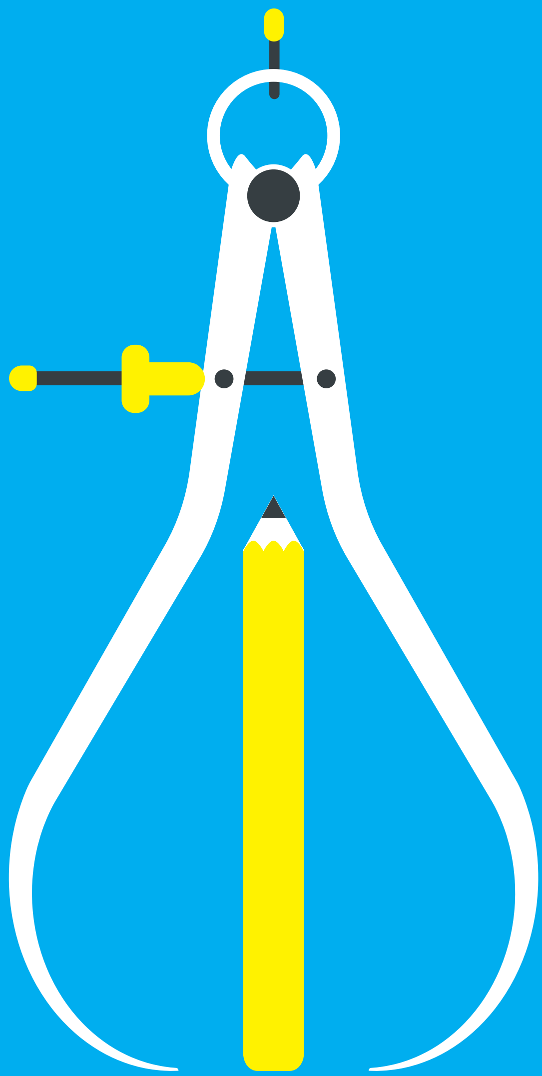
- understand and use the properties of materials and the performance of structural elements to achieve functioning solutions
- understand how more advanced mechanical systems used in their products enable changes in movement and force

They may also:

- understand how electrical and electronic systems can be powered and used in their products [for example, circuits with light, sound and movement as inputs and outputs)
- apply computing and use electronics to embed intelligence in products that respond to inputs (for example, sensors) and control outputs (for example, actuators) using programmable components [for example, microcontrollers)

DISCOVER

Taking a number of bridges over the River Thames as examples and inspiration, students will explore and use the ways that the properties of materials and structural elements contribute to the design of a bridge. They will identify and consider solutions to some of the practical problems associated with bridge design and building, such as creating load-bearing strength while avoiding interruption to water flow and river traffic. And they will begin to consider the design of an exhibition on the Bridges of the River Thames for a younger audience. You may chose to draw on the Connect lesson first, to form an over-arching design brief for the teaching sessions.



LESSON 1
FIVE WAYS TO CROSS A RIVER

THE BIG IDEA

What are the different types of bridge and how do they cope with the loads put on them?

LEARNING OUTCOMES

Could research and explore the way forces affect bridges and discuss how to explain this information to the intended user group.

Should categorise bridges into five different types so as to understand the performance of structural elements and develop these ideas into specifications for products for the final exhibition.

Must communicate their understanding that bridges can be categorised by the way they are designed to accommodate loads.

RESOURCES

Resource 1.1: Thames bridges

Resource 1.2: Understanding bridges

Resource 1.3: Testing the strength of beams

Resource 1.4: Reinforcing beams

Resource 1.5: Cantilevering bridges

Resource 1.6: More Thames bridges

Resource 1.7: Map of the Thames

LESSON 1
FIVE WAYS TO CROSS A RIVER

YOU WILL ALSO NEED

- Tripods or wooden blocks
- Slotted masses (or other regular masses, such as washers or marbles)
- Paper: scrap paper, but not material that has been torn, crumpled or folded
- Card: 120 and/or 160 gsm
- Scissors
- Wood splints
- Straws
- Plastic construction material such as corrugated plastic (3mm is ideal)

MATHEMATICAL SKILLS

- Graphical fluency
- Working with measures
- Patterns and relationships

LESSON 1: FIVE WAYS TO CROSS A RIVER

KEY LANGUAGE

KEY WORD	EXPLANATION
Span	The part of a bridge which crosses a gap.
Deck	The part of a bridge which vehicles or users travel on to cross the span. The deck will also pass over the abutments at the side of a bridge and any supporting piers.
Pier	A support structure for a bridge.
Pylon	A tall support structure for a bridge. Pylons rise above the deck of the bridge and support it via cables from above.
Abutment	A support structure at the side of a bridge. Abutments receive forces transmitted by arches.
Beam bridge	A bridge consisting of a beam, supported from below by two or more piers.
Arch bridge	A bridge in which the force from a load at the centre of a span is distributed by way of an arch to abutments at the side of the bridge.
Suspension bridge	A bridge in which the force from a load at the centre of the span is distributed by way of an overhead cable to abutments or anchor points at the side of the bridge.
Cable-stayed bridge	A bridge consisting of a beam, supported from above, by cables stretched from one or more piers.
Cantilever bridge	A bridge in which the force from a load at the centre of the span is counter-balanced by forces on the other side of a pier.
Truss bridge	A bridge in which the beam is strengthened by the addition of trusses. Also known as a girder bridge, as most trusses are made of lengths of metal known as girders.
Girder bridge	See truss bridge.

LESSON 1: FIVE WAYS TO CROSS A RIVER

SETTING THE SCENE

London has some fantastic bridges. They are elegant landmarks that demonstrate the best technology and the social and economic context of their time.

The Thames is both an asset and a challenge for London. The river brings the benefit of water, fertile land and trade to the city but hinders the movement of people and goods from South to North. The social and economic development of London has always depended on ways of crossing the river. As London expanded in the eighteenth and nineteenth centuries, the heavily congested, solitary crossing point of London Bridge was clearly insufficient. Bridge building flourished, increasingly using new technology and materials, such as London's first cast-iron bridge at Vauxhall in 1816. Isambard Brunel added a suspension bridge at Charing Cross. New materials were found for the railway bridges at Charing Cross, Blackfriars and Cannon Street. One of the world's most iconic designs was produced for Tower Bridge. Innovation on the river continues today, with the "flat-suspension" design of the Millennium Bridge and the cable-stayed footways of the Jubilee bridges.

The basic purpose of any bridge, of course, remains the same – to cross a gap and to be strong enough to stop loads from falling into the gap. Gravity exerts a force that will pull the load into the gap, therefore the bridge must exert a force that opposes gravity. (For simplicity, the task sheets refer to weights, measured in grams.) Drawing on London examples, this lesson introduces three categories of load-bearing bridge design: bridges supported from below: beam and arch bridges; bridges supported from above: suspension or cable-stayed bridges and bridges supported from the side: cantilevered bridges.

LONDON BRIDGES

LESSON 1: FIVE WAYS TO CROSS A RIVER

ACTIVITIES

STARTER

Explain the significance of London bridges as examples of design and technology in practice and discuss with students why and how people need to cross the river. What are the alternatives to bridges – how did people manage when there were no bridges across the Thames, or for the five hundred years when there was only one?

Hand out Resource 1.1 (page 11), Thames bridges, which shows Cannon Street Railway Bridge, Westminster Bridge, Millennium Bridge and Jubilee Bridge.

Discuss what types of load or forces bridges need to bear. Can students identify any characteristics of the bridges shown that might help with this?

MAIN 1: RECOGNISING TYPES OF BRIDGE

Ask students to consider Resource 1.1 (page 11) and Resource 1.2 (page 12) side by side. Ask them to try to label each bridge type and identify the key structural elements indicated on resource 1.2 (page 12).

MAIN 2: TESTING THE STRENGTH OF BEAM BRIDGES

Hand out Resource 1.3 (page 16) Testing the strength of beams, and the equipment listed above to students working in pairs]. Explain the simplest form of bridge is the beam bridge, and the load a beam bridge is able to bear will depend upon a number of factors. The objective of this activity is to show that load bearing strength of a bridge decreases as the distance between the piers increases.

MAIN 3: REINFORCING BEAM BRIDGES

Hand out Resource 1.4 (page 17) Reinforcing beams. Explain that a simple beam bridge can be reinforced through changes to its structure/shape. The objective of this activity is to show how beams can be strengthened so that they can cross wider spans between piers.

MAIN 4: CANTILEVERING BRIDGES

Hand out Resource 1.5 (page 18) Cantilevering bridges. The objective of this activity is to show that counter balancing forces can be used to increase the span of bridges.

Diferentiation

More mathematically able pupils will be able to collect data and present it as a graph without support (although all pupils will be surprised at the shape of breaking load against span, as it is not a straight line). Less mathematically able students may require support with results, perhaps with sheets with some exemplar results filled in.

More able students can be extended by collecting data for a variety of materials.

PLENARY

Discuss the results of the investigations. How do the results relate to the shape of bridges? Hand out Resource 1.5 (page 18) ask your students to identify each bridge type.

Explain that the class will be working towards creating a portable exhibition on Bridges of the River Thames to share their learning with a local primary school or other year groups. Over the course of the topic they should be thinking about how they might interpret their learning for a young audience.

Homework idea

Ask students to:

- complete the graph from Main 2, Resource 1.3 (page 1.3).
- Identify the position of the bridges in Resources 1.1 (page 11) and 1.6 (page 19)on the map of the River Thames in Resource 1.7 (page 20).
- Think about how these exercises could be adapted for a younger audience.

Careers links

The role of engineers and engineering in bridges and similar structures can be brought to life by inviting professional engineers into school to talk to students while this unit is in process. To arrange a visit from a STEM ambassador you can contact STEMNET (ideally at least once month in a advance):

www.stemnetlondon.org.uk

You may also find Tomorrow's Engineers helpful:

www.tomorrowsengineers.org.uk/Careers_resources/

LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.1: THAMES BRIDGES

The four pictures below show an arch, a beam, a suspension and a cable-stayed bridge. Can you work out which is which?

2. Cannon Street Railway Bridge

4. Jubilee Bridge

1. Millenium Bridge

3. Westminster Bridge

1. THE MILLENIUM BRIDGE
© Tom Simpson
1. CANNON STREET RAILWAY BRIDGE
© Steve Smyth
2. WESTMINSTER BRIDGE
© Steve Smyth
3. GOLDEN JUBILEE FOOTBRIDGES
© Steve Smyth

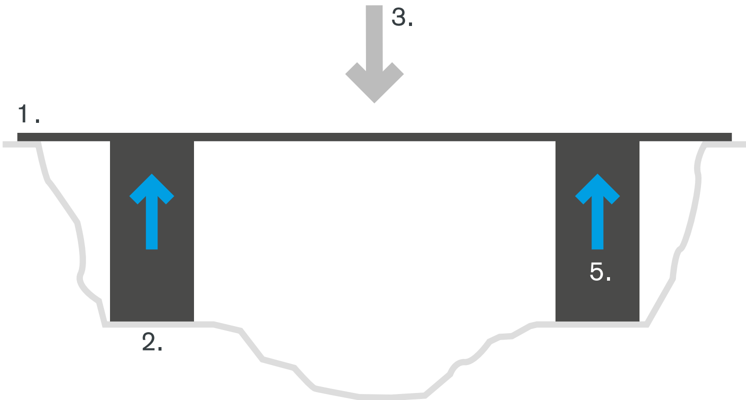
LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.2: UNDERSTANDING BRIDGES

Some bridges can be supported from below.

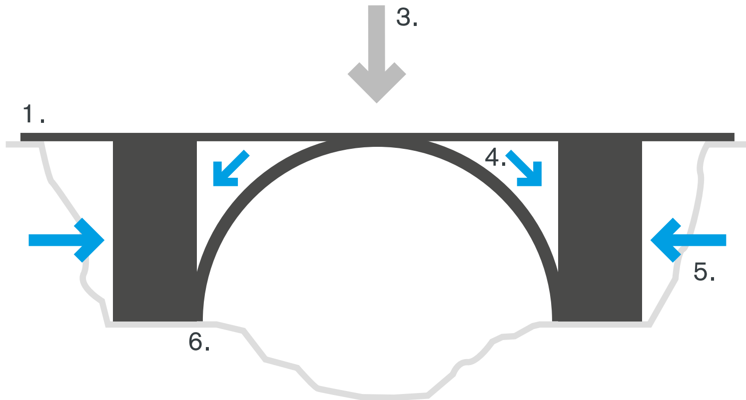
Beam bridges

A bridge consisting of a beam, supported from below by two or more piers.



Arch bridges

A bridge in which the force from a load at the centre of a span is distributed by wayof an arch to abutments at the side of the bridge.



1. Deck
2. Pier
3. Load force
4. Transmitted force
5. Opposing force
6. Abutment

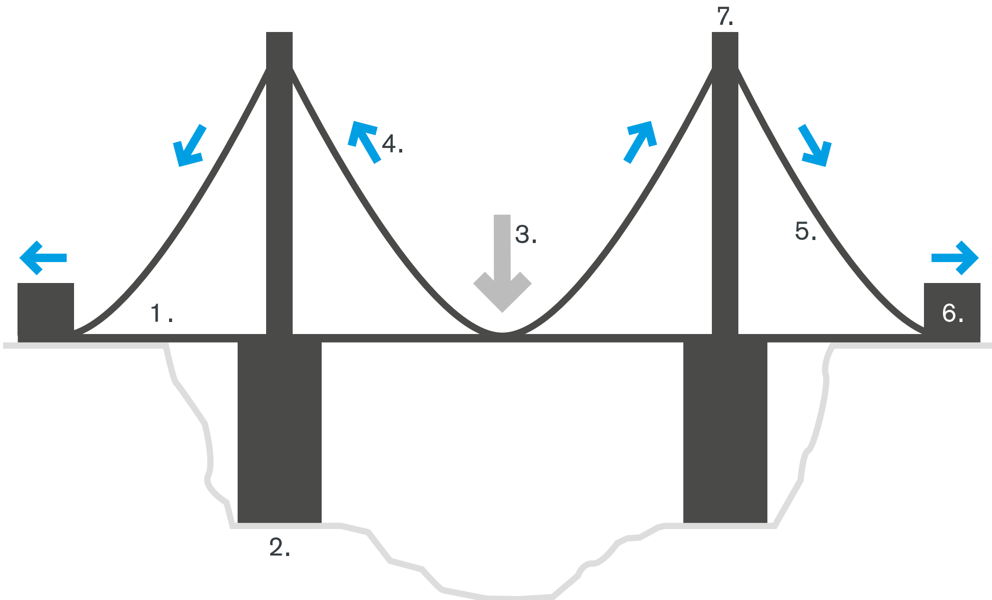
LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.2: UNDERSTANDING BRIDGES CONTINUED

Some bridges can be supported from above.

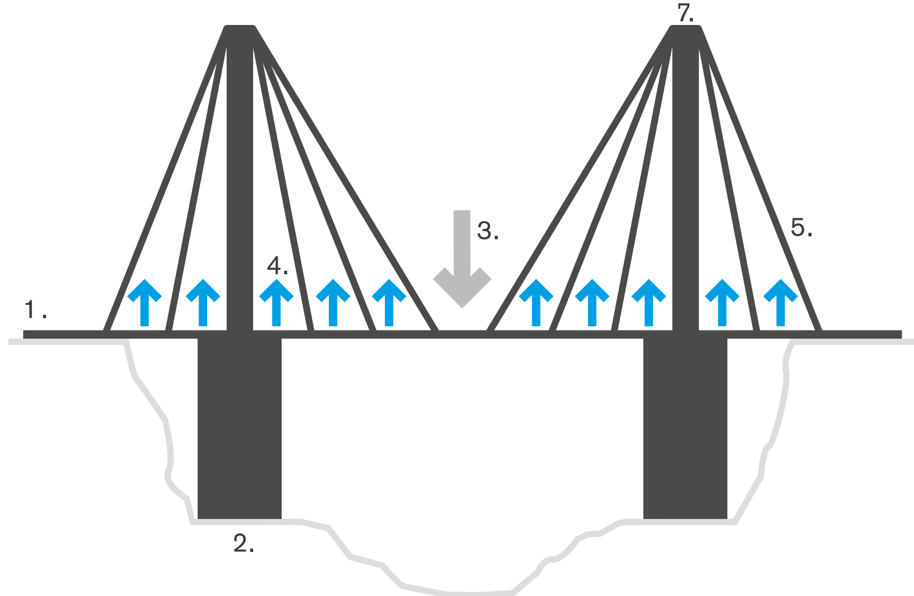
Suspension bridges

A bridge in which the force from a load at the centre of the span is distributed by way of an overhead cable to abutments or anchor points at the side of the bridge.



Cable-stayed bridges

A bridge consisting of a beam, supported from above, by cables stretched from one or more piers.



1. Deck
2. Pier
3. Load force
4. Transmitted force
5. Cable
6. Anchor
7. Pylon

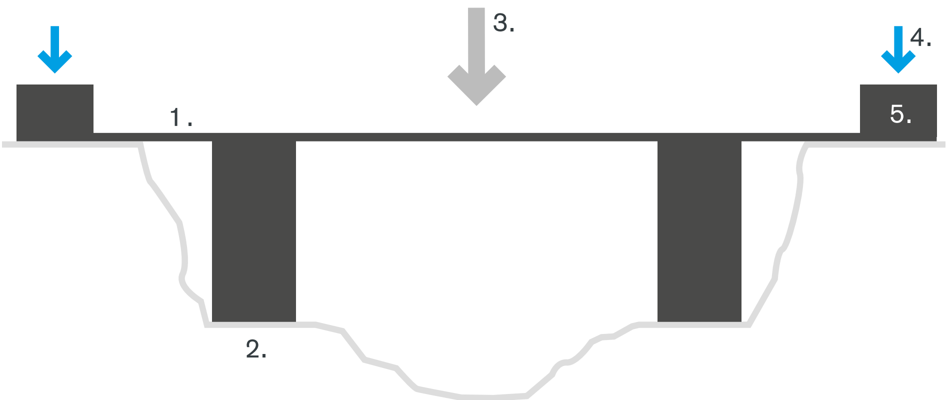
LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.2: UNDERSTANDING BRIDGES CONTINUED

Some bridges can be supported from the sides.

Cantilevered bridges

A bridge in which the force from a load at the centre of the span is counter-balanced by forces on the other side of a pier.



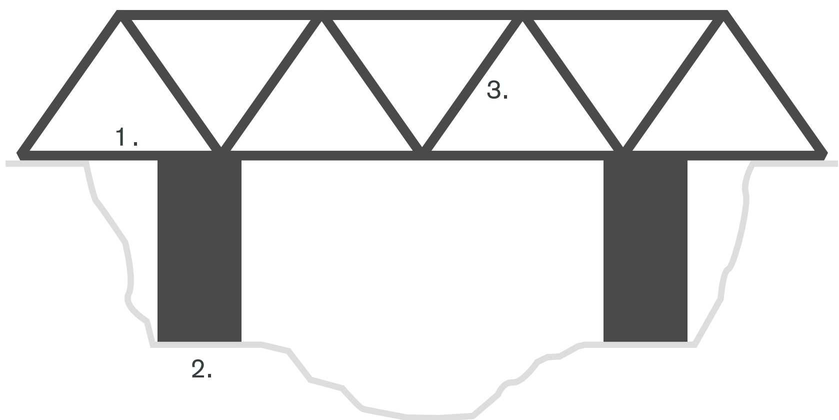
1. Deck
2. Pier
3. Load force
4. Opposing force
5. Counterweight

LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.2: UNDERSTANDING BRIDGES CONTINUED

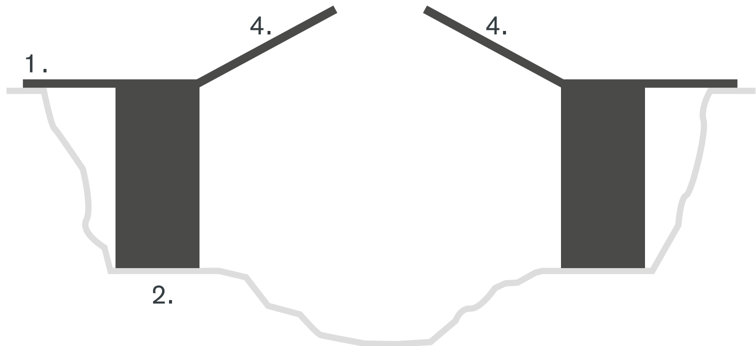
Truss bridges

Bridges are sometimes strengthened with trusses.



Bascule bridges

Sometimes bridges need to incorporate opening sections.



1. Deck
2. Pier
3. Truss
4. Leaf

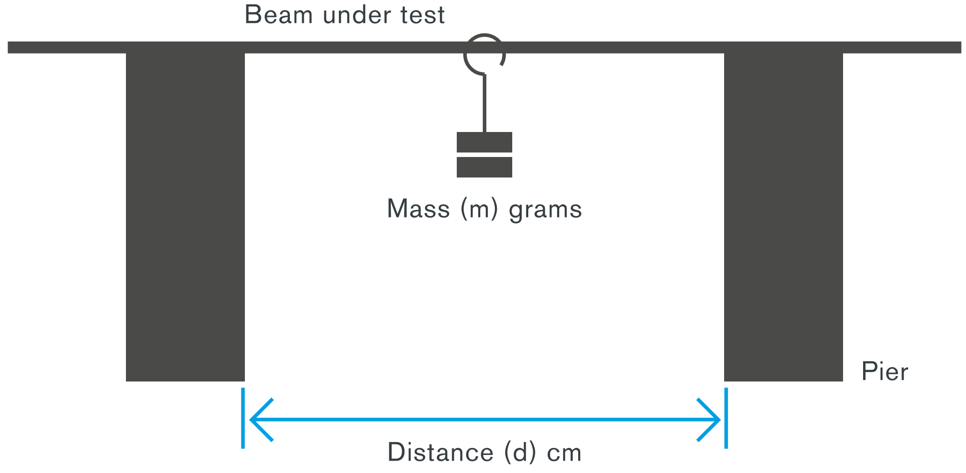
LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.3: TESTING THE STRENGTH OF BEAMS

The task here is to test the strength of a simple beam bridge to destruction!

1. Measure the distance between the two supports.
2. Load the beam with weights until the beam breaks or collapses.
3. Make a note of the distance between the piers and the weight at the point of collapse in a chart like the one shown. Then move the supports 2 cm closer together and repeat. Continue to move the supports closer together and repeat the experiment, recording the results each time.
4. Try different materials for beams: paper, straw, then wood, plastic strip.

Display your results as a line graph for each material, plotting the weight that breaks the beam against the distance between the piers. What do you notice about the shape of the line connecting the points?



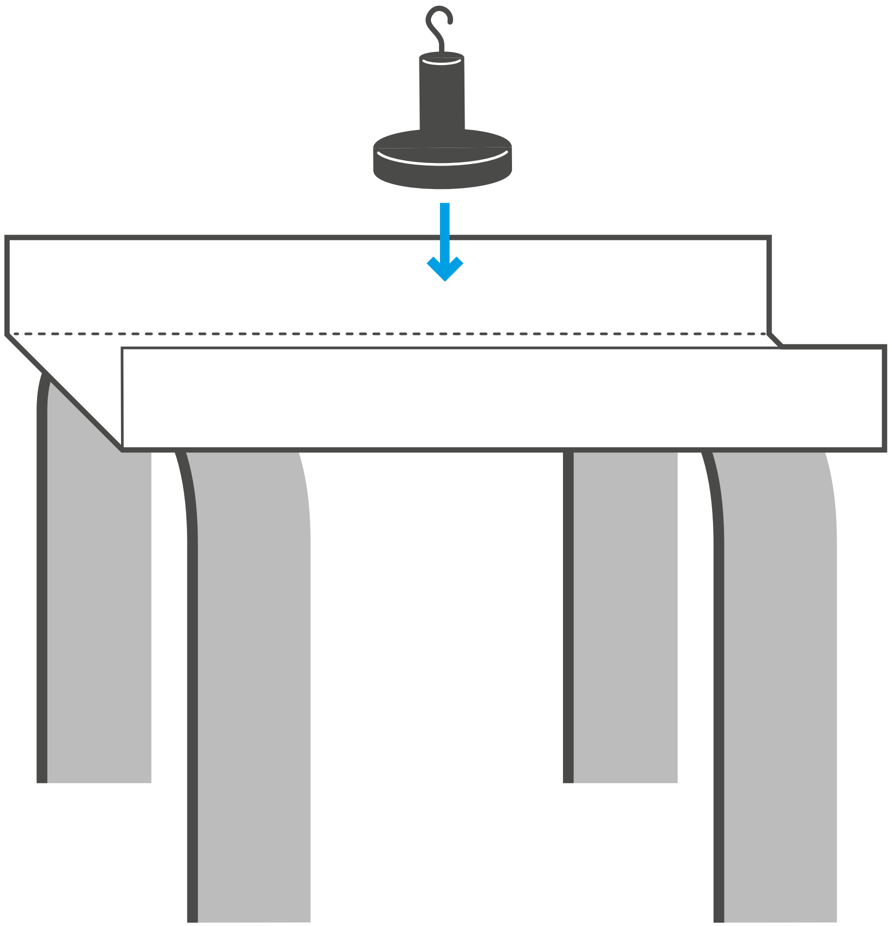
DISTANCE BETWEEN THE PIERS (CM)	WEIGHT THAT BREAKS THE BEAM (GRAMS)

LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.4: REINFORCING BEAMS

You can strengthen a beam bridge by reinforcing the beam. One way to do this is to build sides.

1. Create two paper beams from two sheets of paper of the same size. Make one of the beams from a flat piece of paper. Fold the other piece of paper to give the beam sides, as in the picture.
2. Make both beams into bridges by resting on piers. Find the breaking/collapsing force for these two beams. Make sure the distance between the piers is the same for each bridge.
3. Try folding the paper in different ways, to see if this has any effect on the strength of the beam.
4. Try rolling the paper into a tube and seeing if this has any effect on the strength of the beam.



LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.5: CANTERLEVERING BRIDGES

Repeat the activity shown in Resource 1.3 (page 16), but this time use sellotape to join the ends of the beam to the supporting pier.

You are providing an extra force at the side of the bridge. This counteracts the leverage (turning effect) of the beam at the centre of the bridge. So it is a counter-lever, or cantilever.

You can obtain the same counter-balancing force by placing weights on the beam as shown.

- Using two wooden splints to represent the beam, and two more to act as counter-weights. What is the greatest distance you can bridge between two supports?
- By adding splints to lengthen the beam you can cross greater distances provided you also add new splints as counterweights to counter balance the increased weight of the beam. Try this with a beam that is three splints long. How many splints are needed to balance this beam?
- What distance can be crossed using seven splints? Ten? Fifteen?

LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.6: MORE THAMES BRIDGES

1. ....

2. ....

3. ....

4. ....

5. ....

1. Blackfriars Bridge

2. Waterloo Bridge

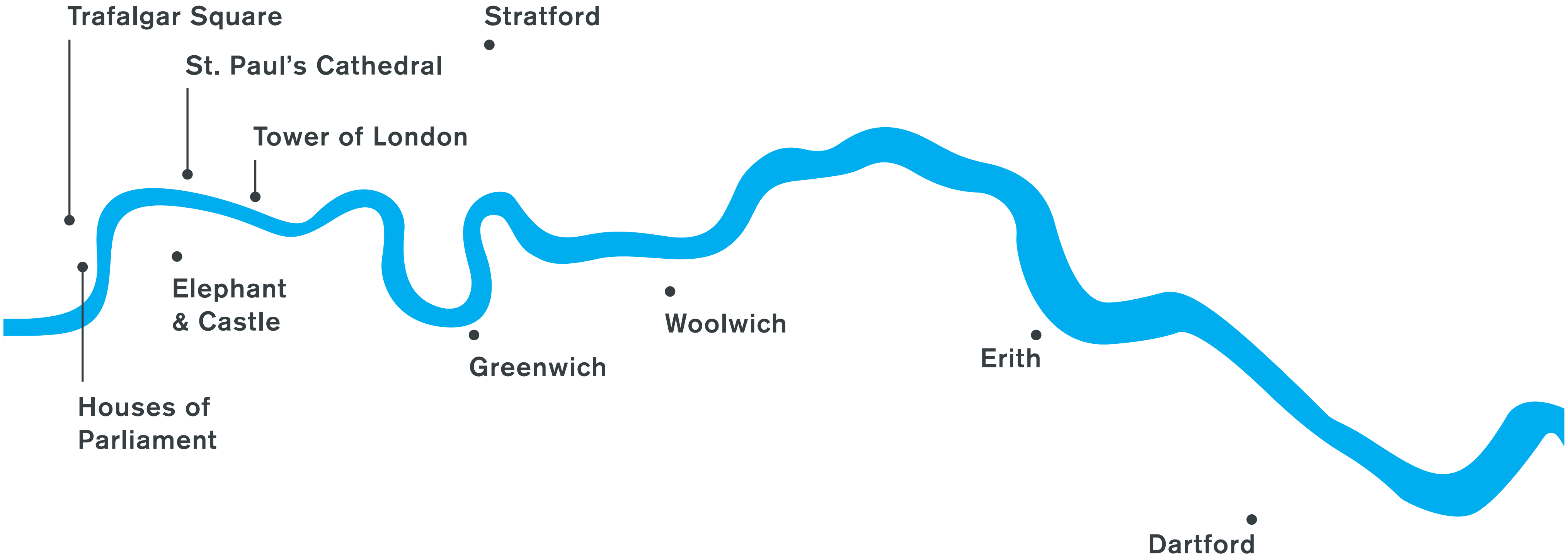
3. Tower Bridge

4. Blackfriars Railway Bridge

5. Southwark Bridge

LESSON 1: FIVE WAYS TO CROSS A RIVER

RESOURCE 1.7: MAP OF THE RIVER THAMES



LESSON 2
WIDER GAPS

THE BIG IDEA

One way to cross wide gaps is to repeat bridge units, such as beams or arches. Piers are then necessary to act as supports for these repeating units. The more piers, the greater the blockage to the flow beneath the bridge.

LEARNING OUTCOMES

Could be able to predict the consequences of putting piers in a river and understand how this affects the development of bridge design.

Should be able to explore the strength of arches and know that as materials and technologies have improved it has been possible to span rivers using fewer piers.

Must know that the distance that can be bridged depends on the strength of the material and that to bridge wide gaps, repeating units may be necessary.

RESOURCES

Resource 2.1: Testing the strength of arches

Resource 2.2: Putting arches together

Resource 2.3: Bridge template

Resource 2.4: The problem with piers

LESSON 2
WIDER GAPS

YOU WILL ALSO NEED

- Tripods or wooden blocks
- Slotted masses (or other regular masses, such as washers or marbles)
- Plastic cups or other similar containers
- Paper: scrap paper, but not material that has been torn, crumpled or folded
- Card: 120 and/or 160 gsm
- Scissors

MATHEMATICAL SKILLS

- Working with measures
- Patterns and relationships

LESSON 2: WIDER GAPS

KEY LANGUAGE

KEY WORD	EXPLANATION
Current	The speed at which water flows in a river.
Constriction	Artificial narrowing of a river. Constrictions cause an increase in the current of a river.
Tide	Movement of water caused by the gravitational attraction of the sun and the moon.

LESSON 2: WIDER GAPS

SETTING THE SCENE

Beam bridges are useful for crossing narrow gaps, but the arch was a huge leap forward in technological terms. Putting a series of arches together enabled builders to construct a strong, long lasting structure across the Thames.

Old London Bridge, built under the direction of a priest Peter de Colechurch between 1176 and about 1203, was made of stone and had 19 arches. Unlike earlier structures, this bridge lasted for six centuries.

The problem with so many arches was that the piers constricted the flow of the river, making the current between very fast indeed. It was very difficult to row a boat up the river through London Bridge, and very dangerous to take a boat in the other direction because the flow was so rapid. Many boats overturned at London Bridge, and boatmen and passengers were frequently drowned. Shooting the rapids also became a well-known, if hazardous pastime!

This lesson explores the technology of arches and the impact of repeating bridge 'units'.

THE VIEW OF LONDON BRIDGE FROM EAST TO WEST, 17TH CENTURY
anonymous © Museum of London

LESSON 2: WIDER GAPS

ACTIVITIES

STARTER

Discuss with the students the homework they have completed from Lesson 1 . What are the main types of road crossing? (Arch bridges). How many arches do the various bridges have? Why are there no single arch crossings among these bridges?

MAIN 1: TESTING THE STRENGTH OF ARCHES

Hand out Resource 2.1 (page 27)and the equipment listed to students working in pairs. Explain the activity, the objective of which is to test the strength of arches, and to show how different materials affect the strength of an arch.

Differentiation

More able pupils will be able to extend this activity by collecting data for different thicknesses of card and paper.

MAIN 2: PUTTING ARCHES TOGETHER

Hand out Resource 2.2 and 2.3 (page 28 – 30). Explain that the objective is to build a series of repeating arches which can be tested to destruction. The design can be used with different thicknesses of paper and card to show how different materials affect the strength of arches. Ask students to try loading the bridge with slotted masses and with small weights in plastic cups (or other suitable containers). Although slotted masses may be available for testing in the school laboratory, this may not be the case if an exhibition is sent out to a primary school, so other methods of loading may need to be tried.

Differentiation

The lines A and C on the bridge template are included as extensions for more able and more dextrous pupils. Using line C will give a sharper curve than line B, and this will result in a higher arch. Line A is horizontal and so will result in a beam rather than an arch. Both of these shapes can be investigated in the same way as bridges built using line B.

PLENARY

Show students Resource 2.4 (page 31) the problem with piers. Discuss the questions on the sheet, explain that while stronger modern materials have reduced the need for so many piers, bridges can also be supported from above, so reducing the need for piers below. Explain that suspension bridges will be the focus for the next lesson.

Homework idea

Ask your students to make sketches of up to three bridges in the area around their home and school. Ask them to mark your bridges on a sketch-map of the area. What type of bridge is each sketch?

Ask students to think about how these exercises could be adapted as activities for a younger audience.

LESSON 2: WIDER GAPS

RESOURCE 2.1: TESTING THE STRENGTH OF ARCHES

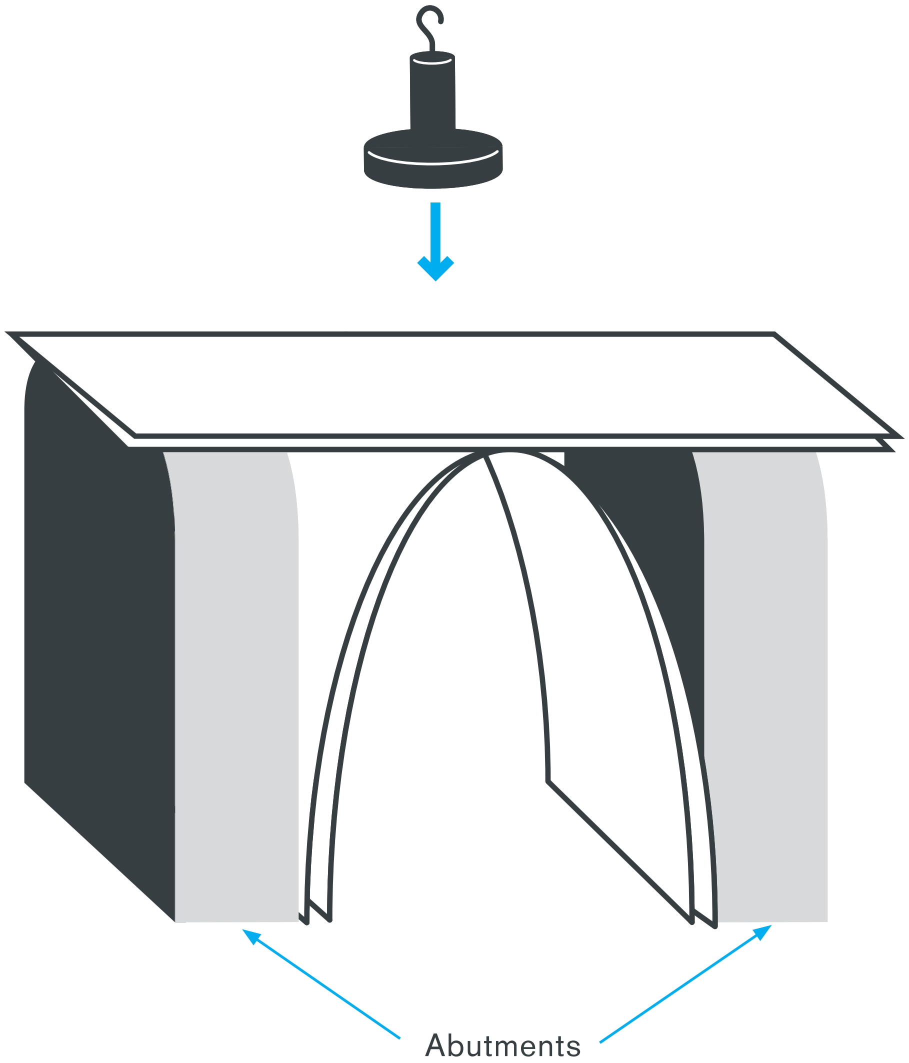
Using two blocks and a piece of paper folded into a strip, create a simple beam bridge. Place weights on the bridge in the middle of the deck until it collapses. Record the weight that collapses the beam.

Now recreate the beam bridge but then support the paper deck with a second piece of paper, curved to form an arch support as in the diagram.

An arch bridge works by distributing the load from the bridge to the abutments. Try loading the piece of paper between two blocks with the same weight that caused the simple beam bridge to collapse.

Now try moving the supports further apart, so the curve of the arch is altered. Does this make a difference to the load that can be supported?

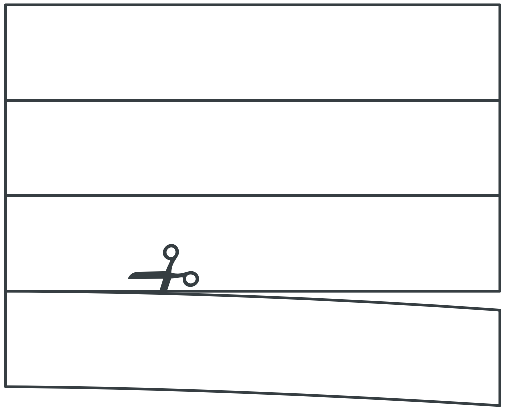
You may need to fix the abutments in place to stop the bridge collapsing. But if the bridge does collapse, it shows how it works – the abutments are pushed apart by the downward force on the deck.

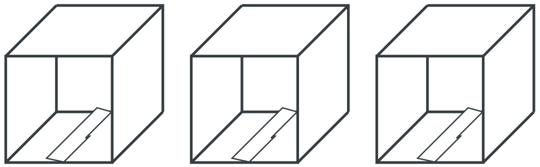


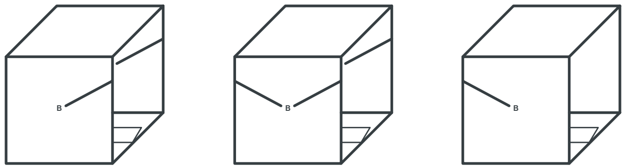
LESSON 2: WIDER GAPS

RESOURCE 2.2: PUTTING ARCHES TOGETHER

Your task is to build a series of arches and test their strength. You can try changing the thickness of the material and also the curve of the arch.







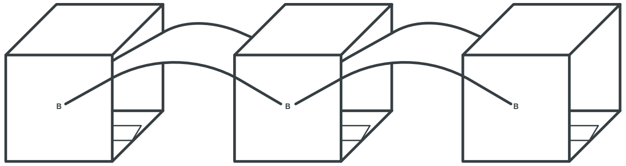
1. Fold a piece of card to make four equal strips. Cut the strips out.

2. Cut three abutment strips from Resource 2.3 Bridge Template. Cut the two solid lines and fold along the dotted lines. Slot the two cuts together to make three square abutments.

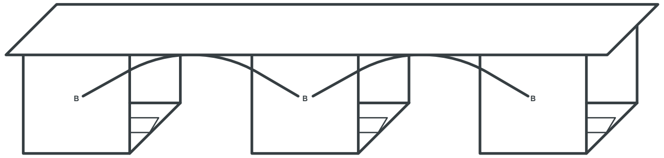
3. Make two cuts in each abutment along the lines labelled B. You only need to use one cut on the central abutment for the moment, but you may need the other cuts later to extend your bridge.

LESSON 2: WIDER GAPS

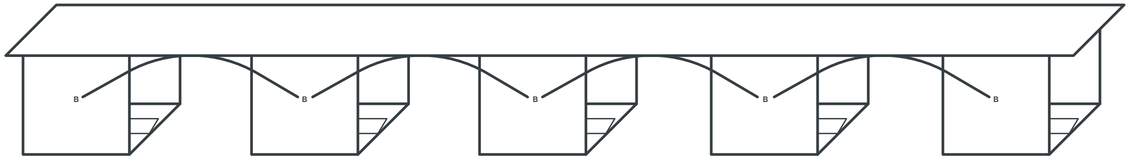
RESOURCE 2.2: PUTTING ARCHES TOGETHER CONTINUED



4. Put two card strips into the slots in the abutments. You may wish to sellotape down the abutments to keep them from moving apart.

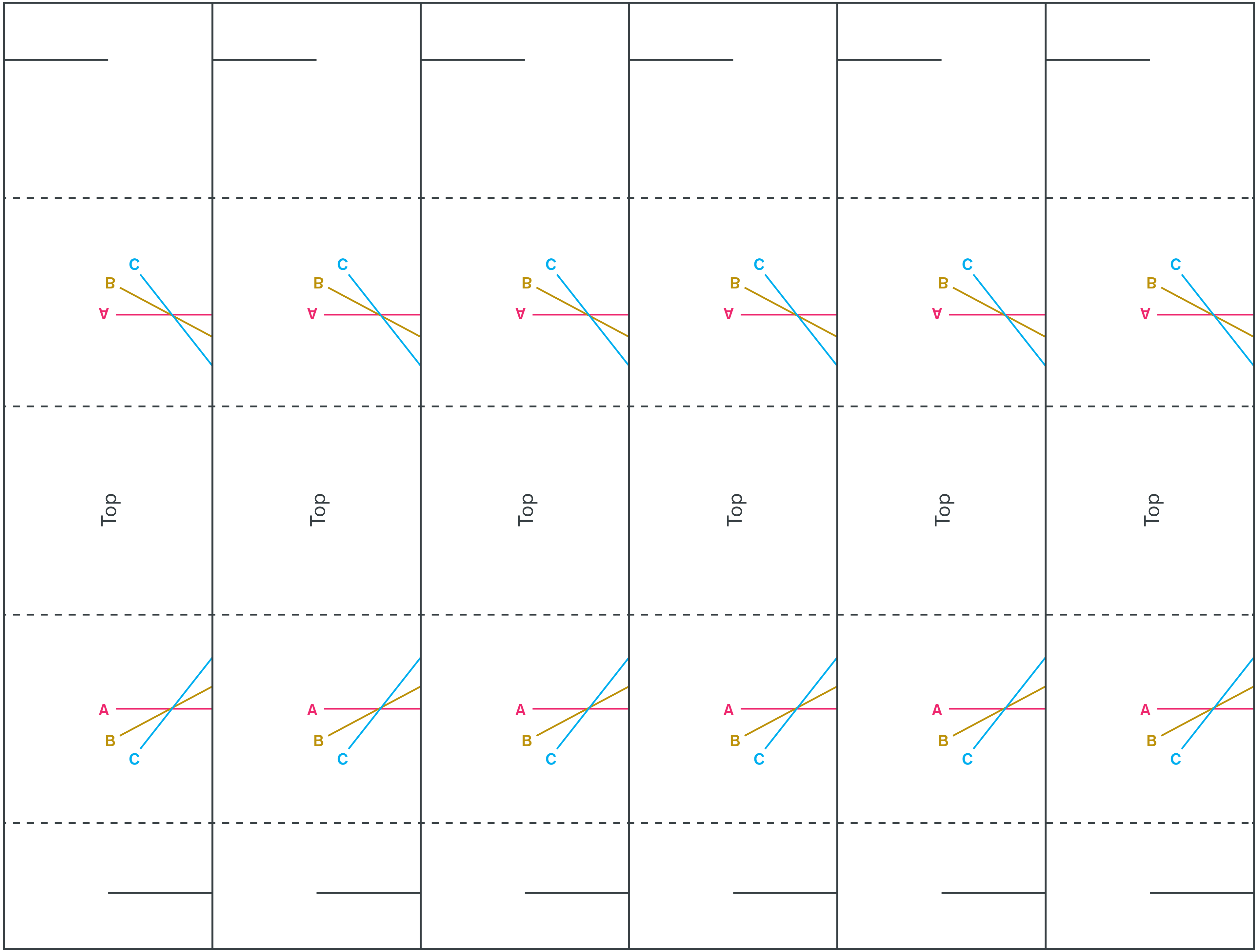


5. Place strips of card across the arches to form a deck.



6. You can extend your bridge by adding more abutments and arches. You can alter the curve of the arch by using lines A and C instead of B in step 3.

Resource 2.3 Bridge Template is shown on the next page (page 30).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Top Top Top Top Top Top
A A A A A A
B B B B B B
C C C C C C

LESSON 2: WIDER GAPS

RESOURCE 2.4: THE PROBLEM WITH PIERS

Old London Bridge, completed in 1209, was a wonder to visitors from other countries, bearing shops, houses and a chapel on twenty arches across the river.

1. What effect do you think that the piers would have had on the flow of the river?
2. Why do they think that "Drowned at the bridge" became a common entry in the registers at nearby graveyards?
3. Can you think of ways today's bridges avoid these problems?

THE VIEW OF LONDON BRIDGE FROM
EAST TO WEST, 17TH CENTURY
anonymous © Museum of London

LESSON 3
SUPPORT FROM ABOVE

THE BIG IDEA

Rather than support bridges from below, where piers may obstruct a river, it is possible to support bridges from above. The traditional way of doing this is with a suspension bridge. However, modern materials have enabled designers to also build "cable-stayed" bridges. Suspension and cable-staying systems cut down on the number of piers required.

LESSON OBJECTIVES

Could design and build models of both the above types that demonstrate the differences between them.

Should be able to explore the loading of suspension and cable stayed bridges.

Must understand that the functioning structural element of a suspension bridge is an inverted arche and that of a cable-stayed bridge is an inverted beam.

RESOURCES

Resource 3.1: A simple suspension bridge

Resource 3.2: Bridge template

YOU WILL ALSO NEED

- Corrugated plastic or stiff card
- Slotted masses
- String
- Sellotape
- Scissors

MATHEMATICAL SKILLS

- Using measures
- Patterns and relationships

LESSON 3: SUPPORT FROM ABOVE

KEY LANGUAGE

KEY WORD	EXPLANATION
Anchorage/anchor point	Part of a suspension bridge that anchors the suspension cable and opposes the loading force on the bridge.
Suspension cable	Flexible material running from one anchor point to another via a tower or pylon. Examples of such materials are string, rope and steel cable.
Pylon	A tower that supports a bridge from above.

LESSON 3: SUPPORT FROM ABOVE

SETTING THE SCENE

Beam and arch bridges are useful techniques, but frequently situations arise where a longer span is required with less obstruction to the waterway beneath. Suspension bridges made of rope have been known for thousands of years in different parts of the world, but are fragile and difficult to use. The development of iron technology during the industrial revolution enabled suspension bridges to be built using iron, and so to be much bigger and more permanent. One example of this was the Hungerford Suspension Bridge, built by Isambard Kingdom Brunel in 1845. The bridge was named after the Hungerford Market of the time, because it was built to connect the market with London south of the river. A huge technological achievement for its time, it was replaced within twenty years by a beam bridge of steel girders for the railway running into Charing Cross. But Brunel's original brickwork is still in daily use, as part of the modern railway bridge. So are the suspension chains – these were re-used on the Clifton Suspension Bridge in Bristol.

HUNGERFORD SUSPENSION BRIDGE, C.1845

William Henry Fox Talbot © Museum of London

The image shown here of Hungerford Bridge taken by photography pioneer, William Henry Fox in 1845 is the oldest photograph in the museum's collection.

LESSON 3: SUPPORT FROM ABOVE

ACTIVITIES

STARTER

Discuss the results of the homework the students have just completed. One way of doing this would be to have a large paper map of the area displayed, and students could add their own results using sticky notes.

Are all of the bridges beam or arch bridges, or are there other types? (The answer will depend on the locality of the school).

Hand out Resource 3.1 (page 36) Ask the students to identify the types of bridge shown.

MAIN

Hand out Resource 3.1 (page 36) A simple suspension bridge and Resource 3.3 (page 38) Bridge template. Provide paper and card, string and sellotape. Ask students to work in pairs to produce a model of a suspension bridge. If time is short, groups of four is a good alternative, with each pair producing one suspension cable and then combining the results to produce a finished bridge. Corrugated plastic is useful as a base for the bridge, but cardboard or wood could be used as alternatives.

The important point about suspension bridges is that the cable should run from anchor points over the towers and then across the bridge. The cable transmits the forces on the bridge to the anchorage in the same way that an arch transmits the forces to the abutments. There is a common misconception that the suspension cable simply hangs from the top of the towers. This misconception is easy to replicate in simple models, as the forces involved are very small and a model made with string stuck to the top of a tower is easier to make than one where the string is properly extended to an anchorage.

Extension

Can you modify this idea to produce a cable-stayed bridge?

Differentiation

Both tasks (suspension and cable-stayed) require manual dexterity and patience, and all student pairs will require support to produce models that demonstrates the scientific principles of the two types of bridge. However, more able students could be challenged to produce models that show the effect of varying the size of the towers (and so altering the curve of the suspension chain), especially the effect of keeping the suspension chain very shallow, as exemplified by the Millennium Bridge.

PLENARY

Discuss the models students have produced. How well do they work? How well do they show the scientific ideas behind suspension and cable-staying? See Resource 1.2 (page 12). How could they be made into exhibits for an exhibition?

Homework idea

Design an exhibit for the bridge exhibition.

LESSON 3: SUPPORT FROM ABOVE

RESOURCE 3.1 THAMES BRIDGES SUPPORTED FROM ABOVE

Millennium Bridge

MILLENNIUM BRIDGE AND ST PAULS CATHEDRAL
Tony Grist © Wikimedia Commons

Jubilee Bridge

HUNGERFORD BRIDGE AND JUBILEE BRIDGE
Man Vyi © Wikimedia Commons

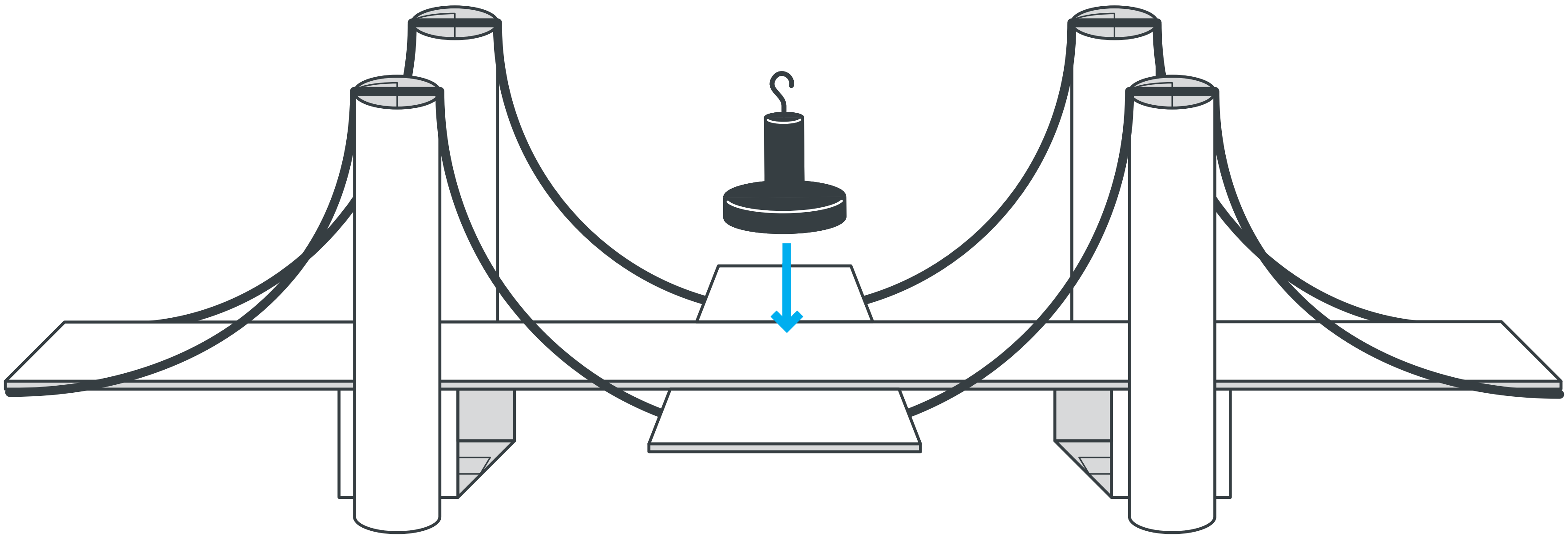
Queen Elizabeth II Bridge

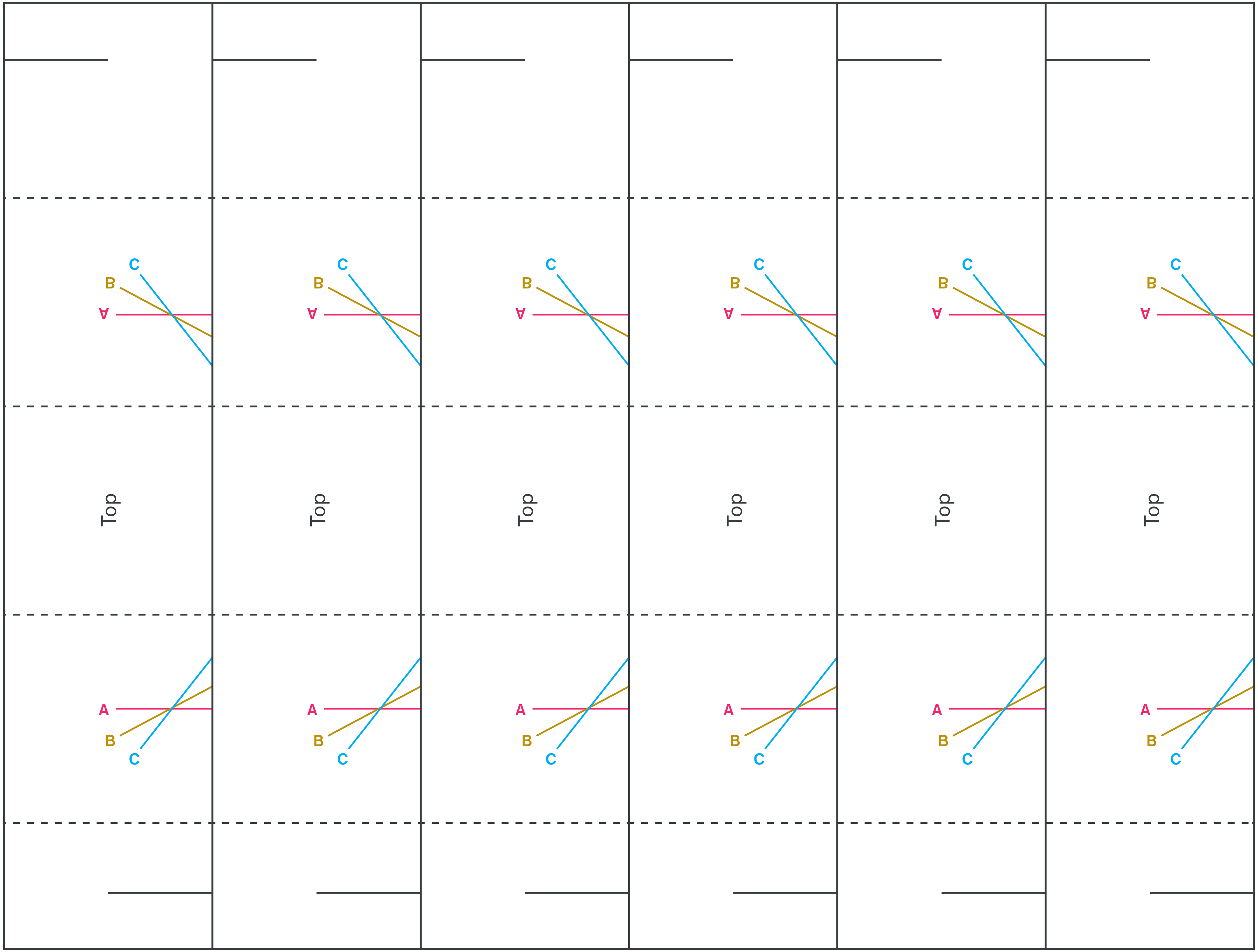
QUEEN ELIZABETH II BRIDGE, DARTFORD
Kenneth Yarham © Wikimedia Commons

LESSON 3: SUPPORT FROM ABOVE

RESOURCE 3.2: A SIMPLE SUSPENSION BRIDGE

- Use the Resources 3.3 (page 38) Bridge template, to create four abutments.
- Make four towers from rolled paper and stick them on the outside of the two inner abutments.
- Run a string from the outer abutment, over the top of the two towers and down to the opposite abutment. Make sure there is a loop hanging between the towers.
- Run a second string between the outer abutments. Adjust the loops so that they follow the same curve.
- Put a strip of corrugated plastic across the two strings in the centre of the bridge.
- Place a longer strip of card or plastic across the abutments and above the central corrugated plastic strip.
- Compare the load you can put on your suspension bridge with the load you can put on an equivalent beam or arch bridge.
- How could you strengthen your suspension bridge?

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LESSON 4
MAKE WAY FOR BOATS

THE BIG IDEA

If a bridge needs to cross a river without obstructing river traffic, it can be built with an opening section. Tower Bridge is a world famous example of a bascule bridge that can open when necessary.

LESSON OBJECTIVES

Could understand how hydraulic and pneumatic systems for operating achieve functioning solutions for lifting bascules.

Should know that different types of opening bridge have been developed by engineers

Must identify and solve their own design problems in order to produce the bridge exhibition.

RESOURCES

Resource 4.1: Balancing levers

Resource 4.2: Exploring pneumatics

LESSON 4
MAKE WAY FOR BOATS

YOU WILL ALSO NEED

- Wood rulers (or strips of 4mm Corrugated plastic)
- Wood or plastic triangles
- Slotted masses
- Syringes of different capacity
- 4mm diameter plastic tubing
- 3mm Corrugated plastic
- Sellotape
- Scissors

MATHEMATICAL SKILLS

- Working with measures
- Patterns and relationships

LESSON 4: MAKE WAY FOR BOATS

KEY LANGUAGE

KEY WORD	EXPLANATION
Bascule	A section of a bridge that can be lifted to allow passage of a boat.
Pneumatics	System of transmitting forces by use of air.
Hydraulics	System of transmitting force by use of liquids (originally by water, hence the name, but in modern technology by use of oils).

LESSON 4: MAKE WAY FOR BOATS

SETTING THE SCENE

Tower Bridge is a great example of designing for a purpose. Throughout the nineteenth century there was very heavy demand on London Bridge, especially after the opening of Surrey Docks – a huge number of wagon movements were necessary to move goods from one side of the Thames to the other. It was obvious that a river crossing below London Bridge was necessary – Marc Isambard Brunel and his son Isambard Kingdom Brunel built the Thames Tunnel at Wapping for this reason, and a ferry was also built across the Thames between Rotherhithe and Wapping in 1878. However, the steep approach roads of the tunnel and the limited capacity of the ferry meant a new bridge was needed.

The difficulty for the designers was that sailing boats with tall masts still used the pool of London (the section of the river immediately downstream from London Bridge). So a bridge would have to be high enough for boats to sail underneath, or would need a lifting section. Eventually the design of Tower Bridge, with its opening bascules, was settled on as being in harmony with the area, especially the Tower of London (from which it gets its name – not from its own towers!).

TOWER BRIDGE OPENING
Tony Hisgett © Wikimedia Commons

LESSON 4: MAKE WAY FOR BOATS

ACTIVITIES

STARTER

Discuss with students why Tower Bridge was built. More on the history of the bridge can be found at:

www.towerbridge.org.uk/bridge-history/

more on the Thames Steam Ferry at:

www.bygonetransport.co.uk/page8.html

Discuss the ideas the students have brought in for the bridge exhibition.

MAIN

Explain that bascules are like levers and that Resource 4.1 (page 44) allows students to explore levers in more depth. Ask students how they might, in turn, explain the ideas of leverage to younger children as part of the bridge exhibition.

Tower Bridge has bascules where the lifting is achieved by hydraulics. Hydraulics is the transmission of forces through liquids. Pneumatics is the transmission of forces through air. The principles are the same, but pneumatics is a lot less messy for use in primary schools, and so it is probably better to use pneumatics rather than hydraulics for the bridge exhibition. Resource 4.2 (page 45) allows students to explore pneumatics, read or show them to re-explain the ideas in the bridge exhibition.

Differentiation

Less able students will require support with the mathematics of both of these activities. They may need sheets with some exemplar results filled in. More able students should be able to spot the patterns fairly quickly and confirm them by collecting further data.

PLENARY

How do the activities tried in this section add to what can be shown in the exhibition? What other ways are there of raising bridges (drawbridges, for example)? What shape will the exhibition have? Allocate tasks to different individuals and groups.

Homework

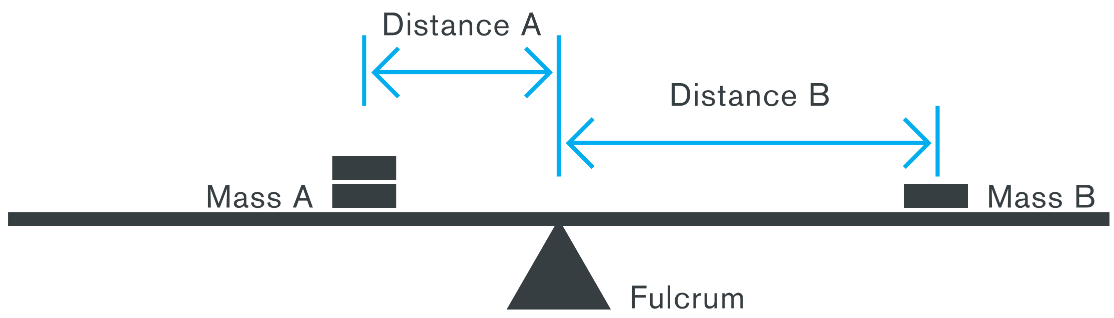
Produce detailed plans for the part of the exhibition that you have been allocated.

LESSON 4: MAKE WAY FOR BOATS

RESOURCE 4.1: BALANCING LEVERS

The opening sections of Tower Bridge are known as bascules. They are like levers pivoting on a fixed point. This activity lets you explore the forces acting on balanced levers, so that you can understand where force can be applied to open the bascules of a bridge.

- Balance a ruler on a fulcrum, like the one in the diagram.
- Place masses on either side so that the ruler balances.
- Try the activity with the ruler off-set (the fulcrum is not at the midpoint).
- Record your results in a table
- What pattern can you see in your results?



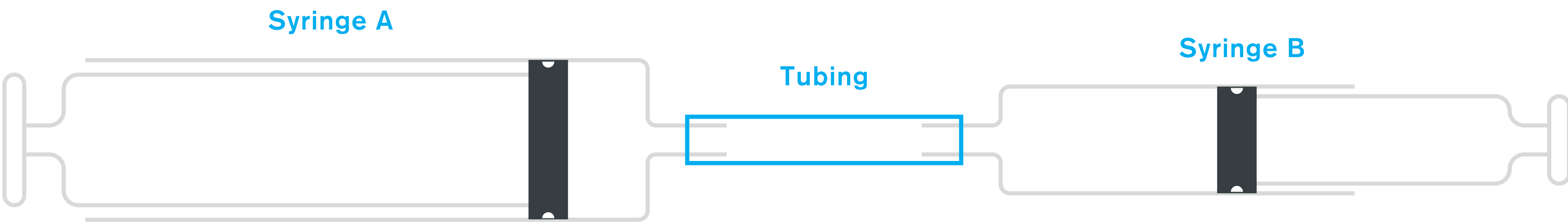
Mass A	Distance A (distance of mass A from fulcrum)	Mass B	Distance B (distance of mass B from fulcrum)

LESSON 4: MAKE WAY FOR BOATS

RESOURCE 4.2: EXPLORING PNEUMATICS

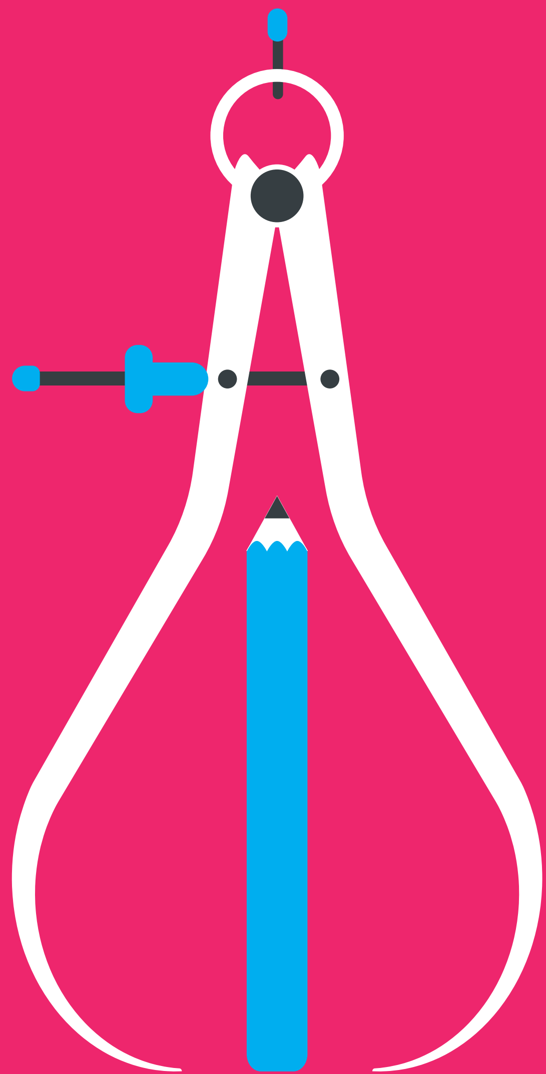
Pneumatics is a system for transmitting force. This activity explores pneumatics so that you can explain how the system can be used for opening a bascule bridge. Tower Bridge uses a similar system.

- Measure the distance of the end of each piston (A and B) from the end of the plastic cylinder.
- Push the piston of syringe B in by 1cm. How far does the piston in A move?
- Push the piston of B by 5cm. How far does the piston in A move?
- Now try a different combination of syringes. Which gives the furthest movement of A for the smallest movement of B?
- Can you use your knowledge of pneumatics to construct a model of a bridge where a span is opened by the operation of a syringe?



EXPLORE

The stretch of the River Thames from Westminster to Tower Bridge passes some of the most iconic bridges in the world. The walk will enable students to immerse themselves in the history, design and technology of London's bridges, and, at the same time provide valuable research information which will help to turn their bridge exhibition into an engaging experience for their audiences.



LESSON 5
A WALK FROM WESTMINSTER TO TOWER BRIDGE

THE BIG IDEA

A walking tour along a stretch of the River Thames between Westminster and Tower Bridge to research the history, technology, design and use of some of the most iconic bridges in the world.

LEARNING OBJECTIVES

Could research by photographing or sketching other features that show similar design features.

Should be able to explain why particular designs were used in particular circumstances. They should also be able to take photographs of key features to use in their display material in order to communicate design ideas.

Must know the structural elements of different types of bridge and be able to allocate particular examples to different categories.

Must know the types of bridge and be able to allocate particular examples to different categories.

RESOURCES

Resource 5.1: Route guide and map section one: Westminster Bridge to Blackfriars Bridge

Resource 5.2: Route guide and map section two: Blackfriars Bridge to Tower Bridge

Resource 5.3: A view from the river

Resource 5.4: Minibridges

Resource 5.5: Bridges and living things

Resource 5.6: Bridges in the landscape

Resource 5.7: How busy?

YOU WILL ALSO NEED:

- Clipboards
- Cameras

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

ACTIVITIES

PREPARING FOR THE VISIT

A pre-visit to the area is strongly recommended, so you can ensure your students' time is as focused as possible on the day. Walking the tour prior to the excursion will also enable you to check timings and stopping points. Please ensure that the appropriate risk assessment has been undertaken.

To walk the complete distance from Westminster station to Tower Hill station would take about three hours, if allowing time for research and recording. So the guides and maps provided divide the route into two separate sections, each of approximately one and a half hours.

Section one is from Westminster to Blackfriars; Resource 5.6 (page 62)

Section two is from Blackfriars to Tower Bridge; Resource 5.7 (page 63)

Each route includes suggested stopping points, convenient, wide and relatively quiet areas where groups can congregate and the information provided in the route guide shared and discussed.

Activities

Explain to students that their task during the walking tour is to collate information and images to enrich their exhibitions. It is suggested that students are divided into groups of around six. Provide each group with:

- equipment for photographing, sketching and recording
- one copy of the relevant route guide per group (you may wish to nominate a group leader to be the tour guide)
- Resources 5.1 – 5.5 (pages 57 – 61), designed to help structure their recording. You may wish to choose a selection of these resources depending on the focus of their research. Students should be asked to look for features that will both explain their bridge displays, and also bring them to life.

Homework idea

Collate the material recorded during the walk, ready for display in the exhibition.

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

OTHER POSSIBLE SITES

Museum visits

A number of London museums provide an opportunity to supplement students' study of bridges.

The Science Museum

South Kensington, SW7 2DD

The Science Museum has a range of displays, activities and outreach visits that bring bridge design to life.

www.sciencemuseum.org.uk/visitmuseum/Plan_your_visit/exhibitions/challenge_of_materials.aspx

The Museum of London

150 London Wall, EC2Y 5HN

Collections explore the history of the Thames and its bridges.

www.museumoflondon.org.uk/london-wall/

Tower Bridge

Tower Bridge Road, SE1 2UP

A visit to the Tower Bridge Museum offers a chance to see the impressive engineering behind moving the bascules.

www.towerbridge.org.uk/

The Brunel Museum

Railway Avenue, SE16 4LF

The Brunel Museum in Rotherhithe, has models of Brunel bridges.

www.brunel-museum.org.uk/

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

WALKING TOUR: SECTION 1 WESTMINSTER TO BLACKFRIARS STATION

THE LONDON EYE
© Kois Maih

Point 1: The riverside steps up from Westminster Bridge

From this point you can see Westminster Bridge, the upstream Queens Golden Jubilee Footbridge and Hungerford Railway Bridge. There is a good view of the London Eye, which is another kind of example of cantilevering. (The downward force of the wheel's weight is countered by the cables on the other side of the pivot.) You can also see a statue of a large white lion on the far side of Westminster Bridge, which is made of Coade stone; Coade stone was an artificial stone produced by Eleanor Coade, a remarkable scientist and entrepreneur.

Westminster Bridge has seven arches and is 252 meters long. This bridge was built in 1862, replacing the 1759 structure (which features in Wordsworth's poem, *Composed Upon Westminster Bridge*, *September 3rd, 1802*).

The Queen's Golden Jubilee Footbridges are cable-stayed, but the towers are cantilevered out from the pillars of Hungerford Railway Bridge.

The piers for the river-boats are also examples of bridges, mainly of beams, but of interest as the decks are reinforced with railings. They are not fixed because of the need to move up and down with the tide.

Leave point 1 and walk east along the north bank of the Thames (along the Embankment away from Westminster). Cross the Embankment before reaching the junction with Northumberland Avenue – as you walk by Victoria Embankment Gardens you pass a memorial to Samuel Plimsoll, inventor of the Plimsoll line. The memorial was erected by the National Union of Seamen in gratitude for the lives saved by the Plimsoll line, a mark placed on the sides of ships to show how much cargo they could contain and still float safely in different water conditions.

Cross Northumberland Avenue and go up the steps onto the Jubilee Footbridge. Stop mid-way across the bridge.

Point 2: The Queen's Golden Jubilee Footbridge

From here you can look back to Westminster Bridge with the Houses of Parliament beyond. The London Eye is to your left, with a good view of the cabling necessary to keep the wheel upright. The cable-staying on the footbridge is very obvious, as is the fact that the bridge is built onto the original structure of the railway bridge. The Queen's Golden Jubilee Footbridge was opened in 2002 to commemorate the 50th year of Queen Elizabeth's reign (Golden Jubilee).

The railway bridge was built in 1859, but was a replacement for a suspension bridge that was on the site before. The suspension bridge had two brick piers in the river and chains suspended across the towers built on the piers. You can still see the brick piers – they have been incorporated into the structure of the railway bridge. Originally both piers were situated in the river, but the river has been narrowed by the construction of the Embankment (by Joseph Bazalgette; a memorial to him can be seen opposite the Plimsoll memorial, set in the Embankment wall). The northern pier is now adjacent to the Embankment. The designer of the railway bridge, Sir John Hawkshaw, wanted a beam bridge, so additional piers were built to take the weight of the beams and their strengthening girders. Railway bridges need to be fairly rigid, so that the rails don't move under a train and derail it, so most railway bridges are beam/girder bridges or brick arches. If a train crosseswhile you are there you can watch the rails deflect under its weight.

Continue across the bridge and descend to the south bank. Walk east towards, then under Waterloo Bridge. As you walk you can see the downstream Jubilee Footbridge, and, across the river, Cleopatra's Needle, a gift to England from Egypt after the Napoleonic Wars. The obelisk was left in Egypt for over forty years, because of the difficulty of moving it. Eventually a special craft was built to hold the obelisk, which was then towed (with difficulty) back to England. The needle was set up on the Embankment in 1878.

Once past the National Theatre, stop.

Point 3: Embankment by National Theatre

From here you can see Waterloo Bridge to the left and Blackfriars Bridge to the right.

Waterloo Bridge is interesting from a number of different viewpoints. It is a replacement bridge for the original, which was designed by John Rennie that was opened in 1817. Originally called the Strand Bridge, it was then named Waterloo to commemorate the battle of that name. The bridge began to subside in the 1920s, and was closed (a temporary bridge was built to replace it). The replacement wasn't begun until the second world war, when many of the work force that constructed it were women – hence the nick name 'The Ladies Bridge'.

Waterloo Bridge is designed to look like an arch bridge (as the original was an arch bridge) but is in fact a box girder beam bridge, disguised to look like a series of arches. It is clad in Portland stone so that it washes clean in the rain, as concrete would have stained.

Blackfriars Bridge is far simpler. It has five wrought iron arches and is 291m long. It was opened in 1869 and replaced an earlier bridge that had 9 arches. The piers of the road bridge are aligned with those of the following two railway bridges, so that river traffic can move more easily through them. The red columns are all that the remains of one railway bridge, its rail deck removed in 1985.

One other thing you will almost certainly see from here is a crane. There are many working on building sites in central London. Cranes are a very visible way to explain cantilevering – the long (and heavy) arm of the jib is balanced by the heavy weights that are suspended on the opposite site of the pivot point.

Continue along the Embankment under Blackfriars road and rail bridges. The point between the road and first rail bridge was the site of Albion Mill, the first steam powered mill in London, with engines designed by Boulton and Watt. The mill only lasted for five years before it was mysteriously burnt down in 1791.

If you are only completing Walking Tour: Section 1, stop here, just beyond Blackfriars station.

NATIONAL THEATRE
© Kois Maih

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

WALKING TOUR: SECTION 2 BLACKFRIARS STATION TO TOWER HILL

If you are starting the tour here, leave Blackfriars Station by the Southbank exit. Turn right on leaving the station.

Point 4: South Bank at Blackfriars Station

From here Blackfriars Railway Bridge and station is to your left and the Millennium Bridge to your right.

Blackfriars Railway Bridge (originally called St. Pauls) was opened in 1886, and was designed by Henry Marc Brunel, the son of Isambard Kingdom Brunel. It was redesigned in 2012 to extend Blackfriars Station and has a roof of solar panels (it is currently the largest solar bridge in the world). It also has sun pipes and rainwater collection, putting at the forefront of sustainable design.

The Millennium Bridge is a suspension bridge. The suspension chains form a very low arc, so that the views from the bridge are unimpeded. At the time it was built, it was the lowest profile suspension bridge in the world. However, this meant it had little lateral stability, and, when it opened, it had a tendency to wobble as crowds walked over it. The bridge was closed a few days after opening in 2000, and redesigned with features to stop the wobbling effect. The most noticeable of these are the hydraulic shock absorbers, which allow the bridge to move, but only very slowly as the piston pushes against the hydraulic fluid. Once these modifications were made the bridge was reopened in 2002.

THE MILLENIUM BRIDGE
© Tom Simpson

Continue along the riverside path under Southwark Bridge (originally built in 1819 to a design by John Rennie, rebuilt in 1921). The path moves away from the river on reaching Cannon Street Railway Bridge, built in 1869 by John Hawkshaw, the builder of Hungerford Railway Bridge. (As you turn to go under the railway there is a very small metal cover set in the pavement marked LHPC – London Hydraulic Power Company, which is worth noting/pointing out to your audience in preparation for talking about Tower Bridge). The walk continues past the tourist sites of The Clink, Winchester Palace and The Golden Hind. Turn left on reaching Southwark Cathedral and follow the road under London Bridge. About 100 metres after London Bridge, turn left on a path that leads under offices to regain the riverbank. The main route is to the right, but by turning left you will find a widening of the path where you can stop and talk to your audience.

Point 5

South Bank by London Bridge. London Bridge is to your left, but this spot marks the position where Old London Bridge reached the south bank of the Thames. Opposite you can see the church of St. Magnus-the-Martyr. The original bridge, that lasted from 1209 to 1830, ran in front of the church to the point where you are now standing. The bridge had 19 stone arches, as medieval technology could only cross fairly small gaps. In order to generate an income for maintenance and repair, the bridge also had houses on it (these were demolished between 1758 and 1762 to improve traffic flow over the bridge). The number of piers impeded the flow of the river so much that the slow moving water to the west of the bridge could freeze over in winter (and Londoners then held 'Frost Fairs' on the ice). Since the demolition of the old bridge in 1830, the river has never frozen over.

A new London Bridge was opened in 1830, by King William and his wife Adelaide (the white building on the northern bank to the right of the bridge is Adelaide House; it was London's first "skyscraper" – i.e. a building using the steel frame construction techniques that had become commonplace in New York). This bridge was replaced in 1973 by the present structure, and sold to Robert McCulloch of McCulloch Oil. The old bridge was re-erected on Lake Havasu in Arizona, where it was the centrepiece of a new township he was developing. Today it is one of the most visited free tourist attractions in the US.

Continue to walk towards Tower Bridge. You will pass HMS Belfast (guns trained on London Gateway services on the M1). Stop beside The Scoop, an outdoor theatre by the side of City Hall.

OLD LONDON BRIDGE, 1710
{{PD-UK-unknown}} Wikimedia Commons

Point 6: Outside City Hall

Tower Bridge is to your right, the Tower of London directly across the river. The bridge takes its name from its proximity to the Tower, not because there are towers in its structure. You can find the times of opening of the bridge at:

www.towerbridge.org.uk/lift-times/

Tower Bridge was opened in 1894 to ease traffic congestion on London Bridge. At the time, the Pool of London (the part of the river between London and Tower Bridges) was still a very busy port area, with many sailing vessels operating to the wharfs. So that these vessels could still access the Pool, the bridge was built with opening bascules, with a walkway across the top so that pedestrian traffic was not interrupted.

The bascules were operated hydraulically – steam engines pumped water into pistons which were loaded with heavy weights. When the bascules were raised the weights pushed down on the water, which moved the bascules through pistons at the other end of the system. (You can show how the system worked using two syringes connected by plastic tubing – although as air is the material in the tube, this a pneumatic system. Hydraulic systems have water, and nowadays mineral oil, in them). You can see the old machinery if you visit the museum in the bridge:

www.towerbridge.org.uk

Hydraulics was a popular way of transmitting power around the end of the nineteenth century. The London Hydraulic Power Company was set up in 1883 to transmit hydraulic power around London through cast iron water mains. LHPC provided a back-up system for Tower Bridge, and to many offices and shops. Theatre curtains were raised by hydraulic power, as were the lifts in Selfridges.

Eventually the system was replaced by electricity, which is more flexible and has a greater number of uses. Tower Bridge operated its own hydraulic system until 1974 when a new hydraulic motors powered by electricity were installed.

Tower Bridge is also a suspension bridge – the chains on either side support the deck of the bridge running out to the bascules.

Continue east to Tower Bridge. Go up the stairs, over the bridge, then follow the pedestrian path by the side of the Tower and under the roadway to Tower Hill station. Follow the path to the area above the station.

THE SCOOP
© Kois Maih

Point 7: Above Tower Hill Station

This space can be used for recording research made on the final section of the walk after City Hall. There is a sun-dialin front of the station.

With the history of London on a circular time-line. Also of engineering interest is Trinity House, the building with the ornate tower and statue at the top. Trinity House is responsible for light-houses around the English coast.

Homework idea

Collate the material recorded during the walk, ready for display in the exhibition.

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

RESOURCE 5.1: EXPLORING THAMES BRIDGES

Your task is to consider the various bridges on the Thames from boat's point of view

Answer these questions for each bridge:

1. Which section of the bridge is used by boats traveling west (upstream)?
2. Which section is used by boats traveling east (downstream)?
3. How is river traffic directed to the correct section of the bridge?
4. How is each bridge protected from river traffic?
5. What type of boats did you see on the river today? What was the main purpose of their movement?

How could you use this information to enhance the Bridge Exhibition you are designing?

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

RESOURCE 5.2: MINI-BRIDGES

The main bridges span all the way across the Thames. However, as you walk along the river you will see smaller constructions, designed to bridge between boats and the shore. These are normally described as piers or landing stages, but they can also be thought of as bridges in miniature. Your task is to record these bridges and make a note of their design features.

Answer these questions for each 'mini-bridge':

1. What is the purpose of this? Who uses it? How often?
2. How is the bridge section designed to cope with the fact that the level of the river rises and falls.
3. Why does the river level rise and fall?
4. How are the bridge sections designed to be safe, even though they may sometimes be steep and slippery?
5. How are the piers designed to protect waiting passengers?
6. What other devices can you see along the river to enable boats to moor (stop by the side of the river)?

How could you use this information to enhance the Bridge Exhibition you are designing? How could you design a model to show how landing stages cope with the rise and fall of the river?

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

RESOURCE 5.3: BRIDGES AND LIVING THINGS

A hundred years ago, the Thames was a smoggy and smoky environment, which was very hostile to living things. But now it is a clean and natural environment with many kinds of animal and plant life. Your task is to look for, and record, evidence of living things found on or around Thames Bridges.

BUSH GROWING ON LONDON BRIDGE
© Kois Maih

Answer these questions for each bridge:

1. Is there any evidence that birds land on this bridge? What measures have been taken to stop them landing? Why do you think this is?

2. Are there any types of plant growing on the bridge? Can you recognise any particular species? You could photograph them and try to identify them back at school.

3. What type of conditions makes the best environments for plants to grow? Do you find as many plants on brick surfaces as on metal? On railway bridges as on road-bridges? On the east side of bridges or the west?

4. Is there any evidence of plant growth on the piers supporting the bridge? Again, what conditions provide the best environment for algae and mosses to grow?

Take some pictures of the living things you find. Can you think of different ways of presenting your findings in your bridge exhibition?

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

RESOURCE 5.4: BRIDGES IN THE LANDSCAPE

London has one of the best river frontages in the world. The bridges along the Thames, especially in central London, are not merely designed to carry people and vehicles across the river – they must look good as well. Your task is to look at the various ways London bridges have been designed so that they enhance the centre of the city.

Answer these questions for each bridge:

1. Are there any statues or other ornaments on the bridge?
2. Is the bridge painted to enhance it's appearance?
3. Is the bridge decorated in any other way?
4. Is there any evidence the bridge is lit up at night? (You might have to use the internet to check)
5. How is the bridge kept clean?
6. Is there any evidence of graffiti? How is the bridge designed to minimise graffiti?

Take some pictures of the bridge enhancements that you find. Can you turn your pictures into a quiz, where people have to recognise the bridge from a detail of the decoration. What would be a good way of presenting such a quiz in your bridge exhibition?

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

RESOURCE 5.5: HOW BUSY

The bridges over the Thames carry a huge amount of traffic, whether by road vehicle, by train or by foot. This traffic can vary hugely throughout the day. Your task is to survey the amount of traffic crossing each bridge.

You could exchange data with other schools that do this survey at different times of day and different times of year, to build up a more accurate picture of the complex traffic flows.

To survey the traffic on your bridge:

1. Time a five minute period.
2. Count the number of people, cars or trains passing during that time.
3. If there are a number of people in your team, divide the tasks so that some measure northward flow and some measure southward.
4. If you cannot see all the cars on a bridge from your observation point, try and get a measure of traffic density by counting the number of double-decker buses.
5. Average your data if you have made a number of observations, then calculate the traffic flow/hour.

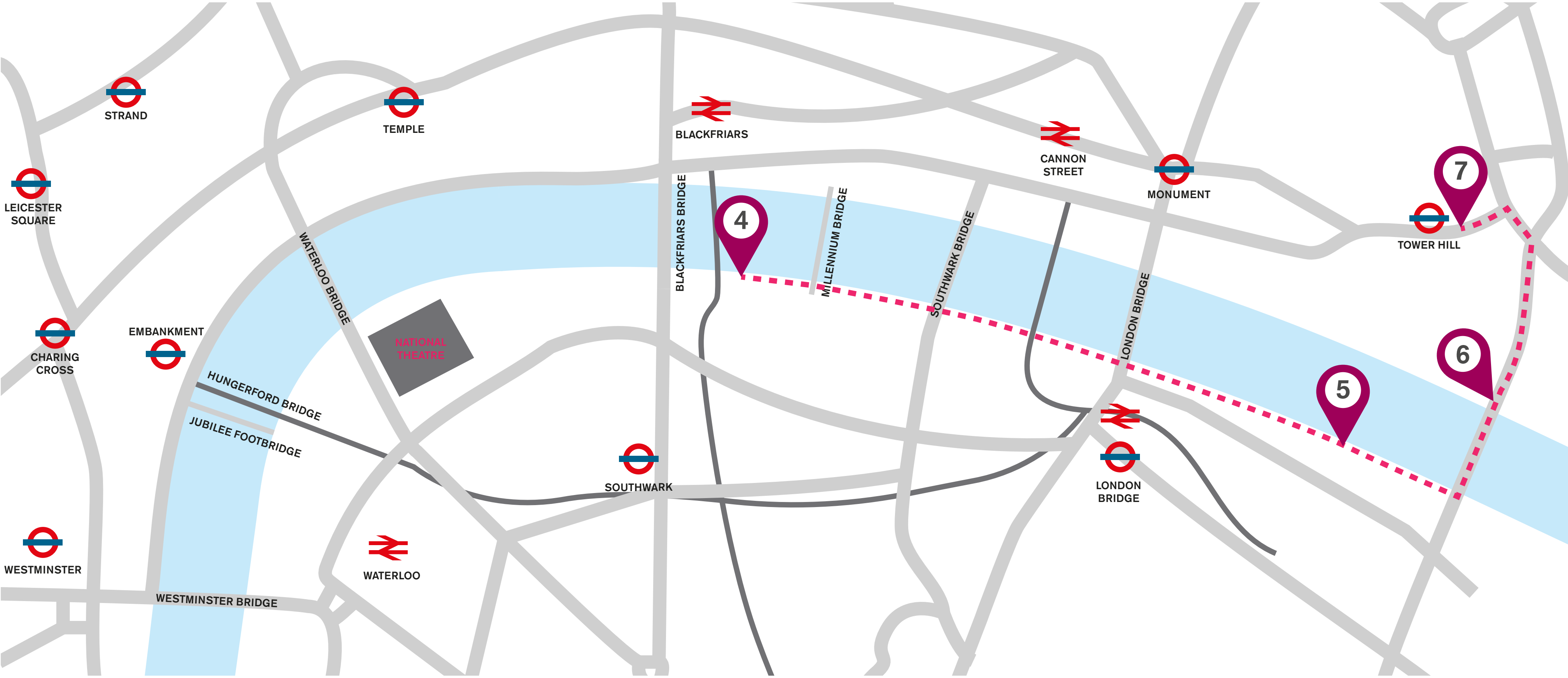
How could you present your results in an interesting way as part of your bridge exhibition?

LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

RESOURCE 5.6: WESTMINSTER BRIDGE TO BLACKFRIARS BRIDGE MAP

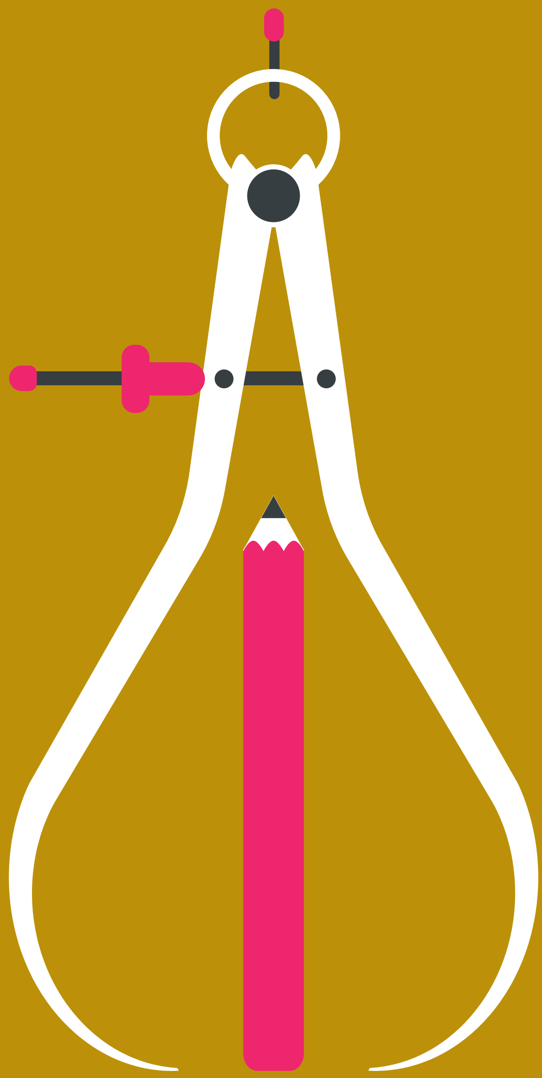
LESSON 5: A WALK FROM WESTMINSTER TO TOWER BRIDGE

RESOURCE 5.7: BLACKFRIARS BRIDGE TO TOWER HILL BRIDGE MAP



CONNECT

Students will design an interactive exhibition for primary schools or other year groups in their own school, celebrating and communicating the design and technology of the iconic bridges of the River Thames.



LESSON 6

A BRIDGE EXHIBITION FOR LOAN TO A PRIMARY SCHOOL

BIG IDEA

Bridges are a huge feature of the River Thames. They also demonstrate important scientific ideas, and show how technology and engineering have evolved. An exhibition about bridges will be very welcome in local primary schools, or by younger or other year groups in your school, especially if the components are built so that the audience can interact with them

LEARNING OBJECTIVES

Could provide a range of labels, diagrams, background information for use with the interactive exhibition in order to communicate design ideas. Evaluate feedback from audiences in order to maintain, improve and enhance the exhibition.

Should develop exhibits that will appeal to a younger audience using a range of resistant and semi-resistant materials and develop a specification as to how these will be packed for transportation.

Must design a series of interactive exhibits in response to the brief above. Work as part of a team to fulfil the brief.

RESOURCES

Resource 6.1: Design brief

YOU WILL ALSO NEED

A range of materials depnding upon the design approach of the students

LESSON 6: A BRIDGE EXHIBITION FOR LOAN TO A PRIMARY SCHOOL

ACTIVITIES

You will need to discuss the interactive tasks that groups develop. Encourage your students to take different approaches which together could produce a varied and stimulating exhibition.

The variety of possible outcomes gives the potential for much differentiation. More able students should be encouraged to produce more ambitious models. Less able students may need support in realising the full educational potential of their exhibits.

An additional consideration will be the weight of exhibits, both for transport and for health and safety considerations when on display – so a lightweight material, such as corrugated plastic, may possibility be useful. This has the advantage that it comes in a range of attractive colours, cutting down on time spent finishing and decorating models. Corrugated plastic can be obtained from the Ivydale Science and Technology Centre:

www.slstc.southwarklea.org.uk

This centre can also provide guidance on building bridge models and also has interesting designs for cable-cars.

One other idea to consider is whether to make any exhibits electrically operated or computer controlled. Lifting bridges can be made with electric motors, as can traffic barriers. Even if you want the realism of using pneumatics/hydraulics for raising the bascules of Tower Bridge, it also has a sequence of warning lights, sirens and moving barriers which can be modelled by students, ready for use by audiences. Models might incoporate sensors to detect when a large ‘ship’ moves past a certain point, triggering automatic sequences of sirens, flashing lights, barriers and bascules. The guidance of river traffic by lights would also provide a good scenario for introducing simple battery operated electrical models. A possibility would be to make a model ‘river’ on a raised platform. Simple paper boats fitted with paper-clips could then be guided by a magnet along the river, through the correctly lit sections of the bridges.

Other ideas involving electricity are ‘matched pair games’, where audience participants need to match two items in order to complete a circuit and thus light a bulb/sound a buzzer.

LESSON 6: A BRIDGE EXHIBITION FOR LOAN TO A PRIMARY SCHOOL

RESOURCE 6.1: DESIGN BRIEF

Primary schools often travel into central London to visit museums or attend plays and concerts. Children on these visits will be familiar with images of the river Thames and its bridges. They will also be familiar with the river and its bridges from films and television.

An exhibition about these bridges will be an opportunity for children to learn more about the science and technology of structures and the geography and history of London. For this age group your exhibition should be as interactive as possible, with plenty of things to touch, move and play with.

Your exhibition should draw on the research that you have undertaken in the Discover and Explore activities. It should try and be as robust as possible, so that maintenance of the different materials and activities does not become a problem. It also needs to be robust so that it can be loaned to a number of local primaries. Finally, it needs to be compact enough to be packed and transported by car from your school to its target audience.

Some questions to consider:

1. What will your specific interactive exhibit be? How will you make sure this does not duplicate other work? How will it fit with the other exhibits?
2. What do you want your audience to learn from your exhibit?
3. How will you make your exhibit interesting to younger children?
4. How will you make your exhibit attractive to younger children?
5. Will you need to provide instructions on how to use the exhibit?
6. Will you need to provide background information for your exhibit – perhaps detailing some of the history of a bridge, or showing a picture of a previous structure on the site? What materials will you use for this?
7. How will your exhibit be packed, stored and moved? Remember, it may not be you who reassembles your exhibit – it may be a teacher or a parent who is unfamiliar with the display.

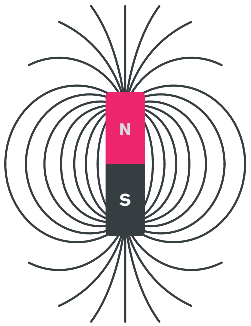
LINKS TO OTHER LONDON CURRICULUM SUBJECTS

The River Thames STEM theme

This unit is part of a set of three exploring the technology and science of the River Thames.

SCIENCE – BIOLOGY

The Living River explores the Thames' changing ecosystems.

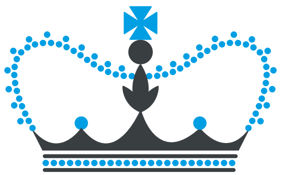


SCIENCE – PHYSICS

The force of the river covers forces and pressure in the context of the working life and flood defences of the river.

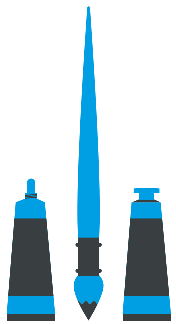
LINKS TO OTHER LONDON CURRICULUM SUBJECTS

The River Thames features in a number of other London Curriculum subjects, creating the possibility of a cross curricular visit.



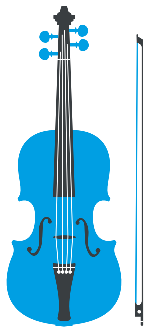
ENGLISH

Tales of the River explores the Thames in writing, as a metaphor for writers' hopes and fears and the city itself.



ART & DESIGN

Riverscape features the dynamic life of the River Thames captured in art



MUSIC

Global City explores the musical impact of London's global and maritime history.

CREDITS

The GLA would like to thank the following organisations for their contribution:

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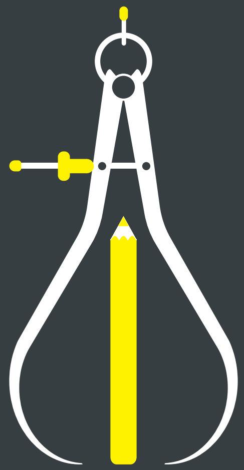

‘The idea of using London as a teaching resource has never been explored much before, so both students and teachers are excited about it’

Key stage 3 teacher

‘It makes me feel proud to be a Londoner’

Key stage 3 student