Chapter Li: Cantilever Bridges – Introduction

AIMS & OBJECTIVES

- To know what we mean by 'cantilever'
- To start to recognise cantilever structures
- To use the correct terminology for a cantilever bridge
- To build a simple model cantilever bridge

CONTEXT

Cantilever bridges can span long distances, often over water, whilst carrying heavy loads. In contrast to suspension bridges (covered in *Learning About Bridges Vol 1*) which may be able to span the same distances (if not greater), cantilever bridges are less flexible and therefore able to carry a heavier load.

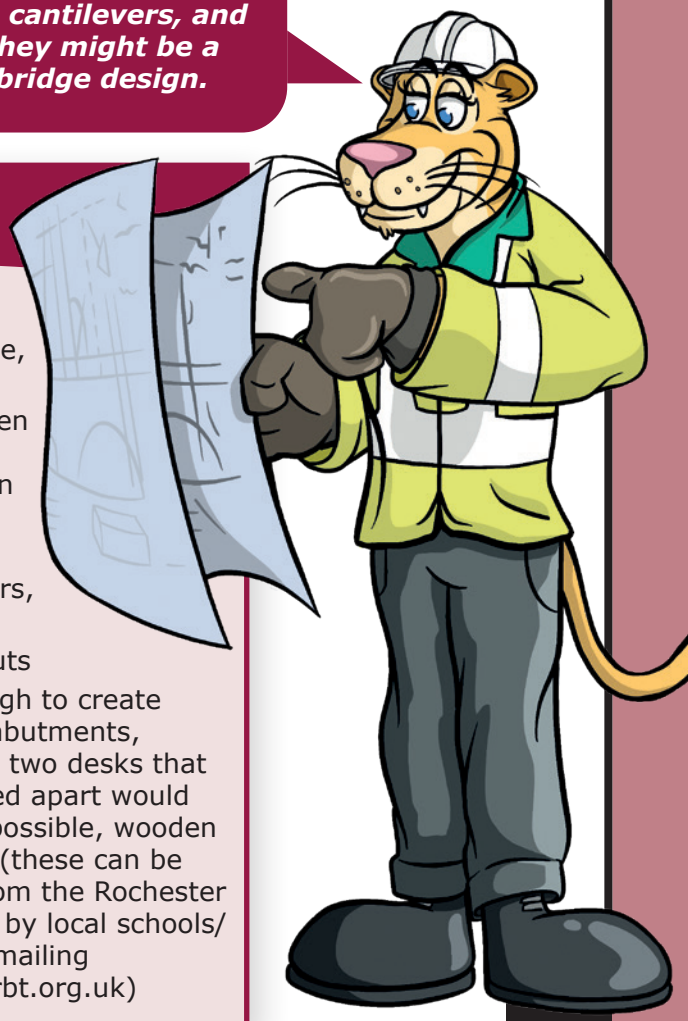
LANGUAGE OF BRIDGES:

Cantilever: A horizontal structure that projects into space at right angles (perpendicularly) to its supporting structure, supported or fixed at only one end.

Compression: a force that tries to make things shorter or smaller (a squashing, pushing force).

Tension: a force that tries to make things longer (a stretching, pulling force).

We are learning about a different type of bridge, cantilevers, and when they might be a useful bridge design.



You will need...

- Handout: *Common structures*
- Resource: *Common Structures*
- Handout: *Cantilever Bridge Terminology*
- Handout: *Cantilever Bridge Challenge*
- Experimenting with levers, per group:

  1st demonstration:
  - A heavy book and a bag with straps, OR
  - 2 dumb bell masses/weight plates of different sizes (e.g. 0.5kg and 2kg)

  2nd demonstration:
  - A ruler
  - A hardback book
  - 9 pennies
  - Paper/note pad and pencil
- Cantilever bridge challenge, per group:
  - Tub of wooden planks, or large wooden craft/jumbo lolly sticks
  - Metal washers, or coins
  - Metal hex nuts
  - Books, enough to create two stacks/abutments, alternatively two desks that can be moved apart would work, or, if possible, wooden bridge base (these can be borrowed from the Rochester Bridge Trust by local schools/ groups by emailing education@rbt.org.uk)

Something to Try:

What is a cantilever?

Give groups copies of the various common structure images from the *Common Structure* resource and/or *Common structures* handout.

Ask learners to see if they can identify a common feature, something they all have in common.

There may be lots of different reasons given, but draw out the ideas that all show they have a structure supported at only one end. This is essentially a cantilever.

Photo by Lehmer and Associates via Shutterstock

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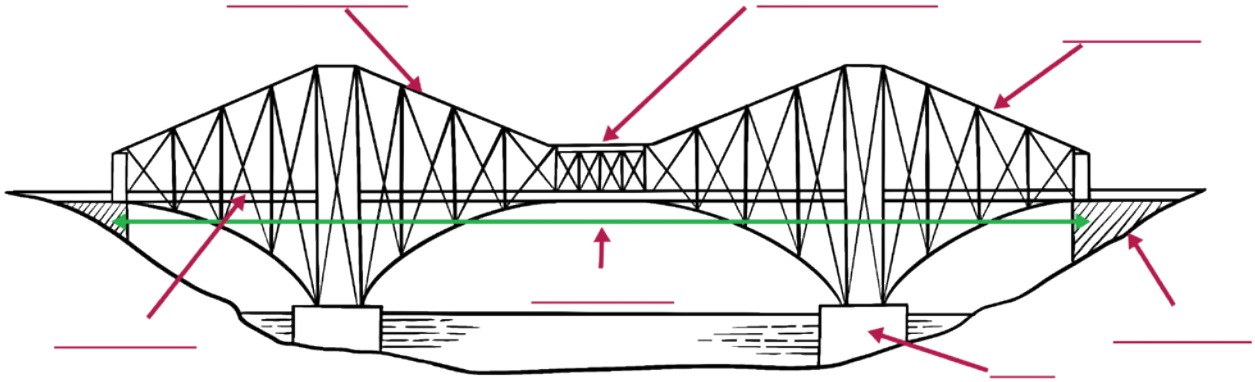
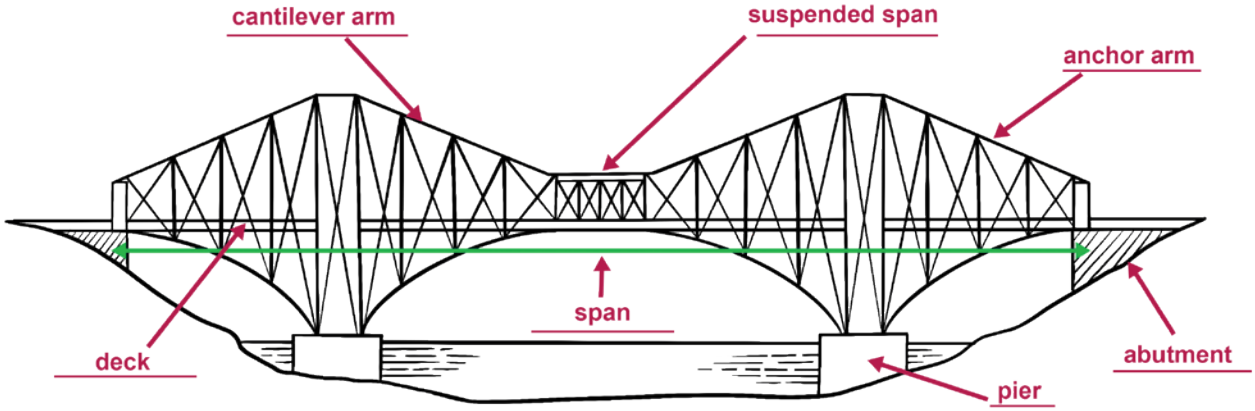
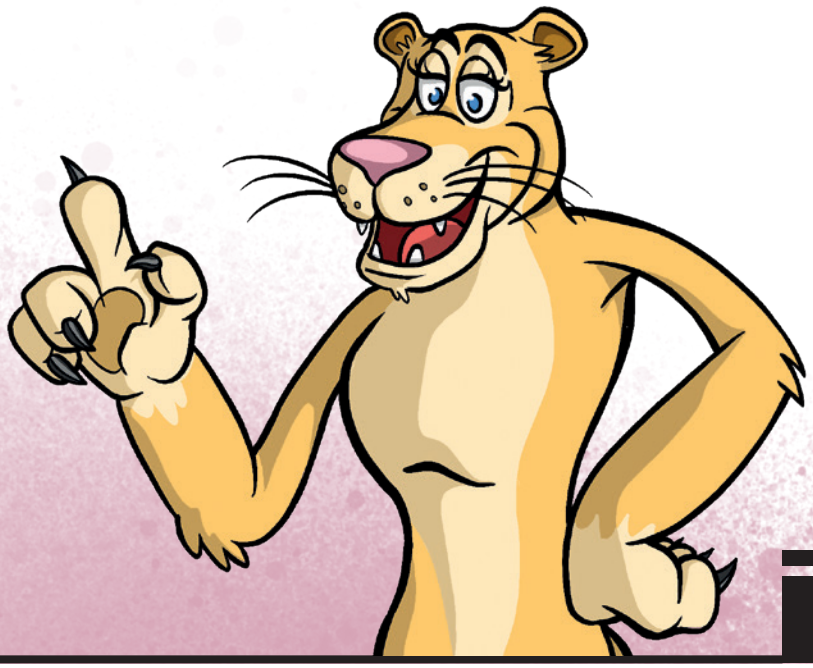
LABELLING THE CANTILEVER BRIDGE:

Give learners a copy of the *Cantilever bridge terminology* handout. Get learners to identify the different parts of the cantilever bridge.





Ask learners what they notice about the bridge – do they recognise any similar structures that relate to their previous bridge sessions?



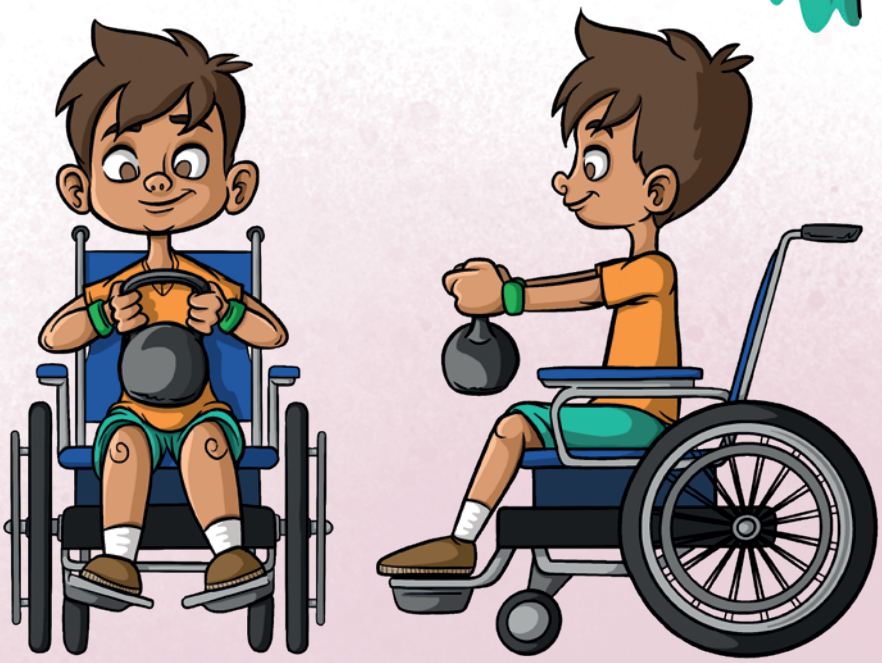
EXPERIMENTING WITH LEVERS:

Learners can do a simple demonstration to show the effect of a lever.

Place the heavy book in the bag with straps, if these are being used instead of the weight plates.

Ask learners if they think they would be able to hold the bag. Those that say 'yes', instruct them to slide the straps over their hand and along their arm, as far as their elbow and hold their arm straight out. Then repeat with the bag over the tips of their fingers.

Ask those taking part, which position was easiest?

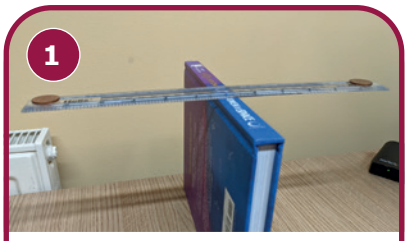


If using weight plates, a similar process applies, but this time, ask one learner to hold the large weight close in to their chest, with both hands, while another learner holds the smaller mass in their hands at full arm's length (with straight arms).

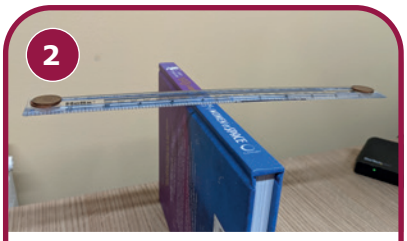
Ask them how long they think they can hold it for. Monitor both learners, asking them whether it is easy; it is likely the learner holding the smaller mass at full length will tire first. Ensure that they can put the mass down (safely) before they get too tired.

Ask learners why they think there is a difference?

Learners can further explore levers and balancing using some simple materials.



1 Balance the ruler on the book with a penny on each end.

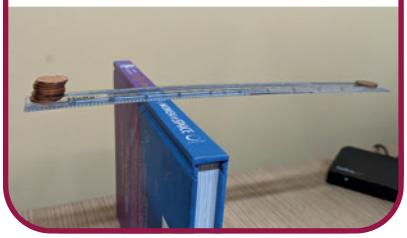


2 Put a second penny, so you have two pennies on one end and slide the ruler along until it balances.

3 Make a note of where the top of the book is, using the centimetre marks on the ruler and write this down.

4 Repeat the same process, but adding two pennies to the end with two pennies, so you now have four pennies on one end.

5 Repeat with six pennies and eight pennies.



This links to science and forces; moments and levers.

Learners should find that the single penny gets further away from the balancing point (fulcrum) as the number of pennies at the other end increases.

Challenge Time!

Who can build the longest span cantilever? Here's a hint: be very gentle with the wooden planks as you move them so you can find their balance point.

CANTILEVER BRIDGE CHALLENGE:

Photo by Mikael Häggström via Wikimedia Commons

This picture shows an early cantilever bridge.

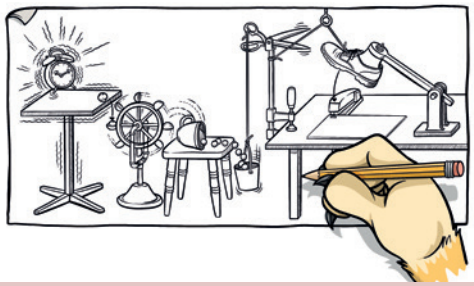
Each group is challenged to build a cantilever bridge using the wooden planks and metal hex nuts, using the *Cantilever bridge challenge* handout.

This offers the chance for learners to experiment with an iterative design process – trying ideas out, testing them watching to see if they fail or succeed, changing their design to improve it, testing again.

HOT TOPICS!

The concept of moments (and levers) relates to simple machines, such as pulleys. This links to Science and Design and Technology. You could ask learners to identify some simple machines – look for scissors, can openers, screwdrivers and even a doorstop/wedge for example. You could explore how levers work to make things easier to do, such as using a screwdriver to open a can of paint.

You could also link to art with work by Rube Goldberg or Heath Robinson. They designed machines that are sometimes described as over-complicated machines for completing simple tasks.



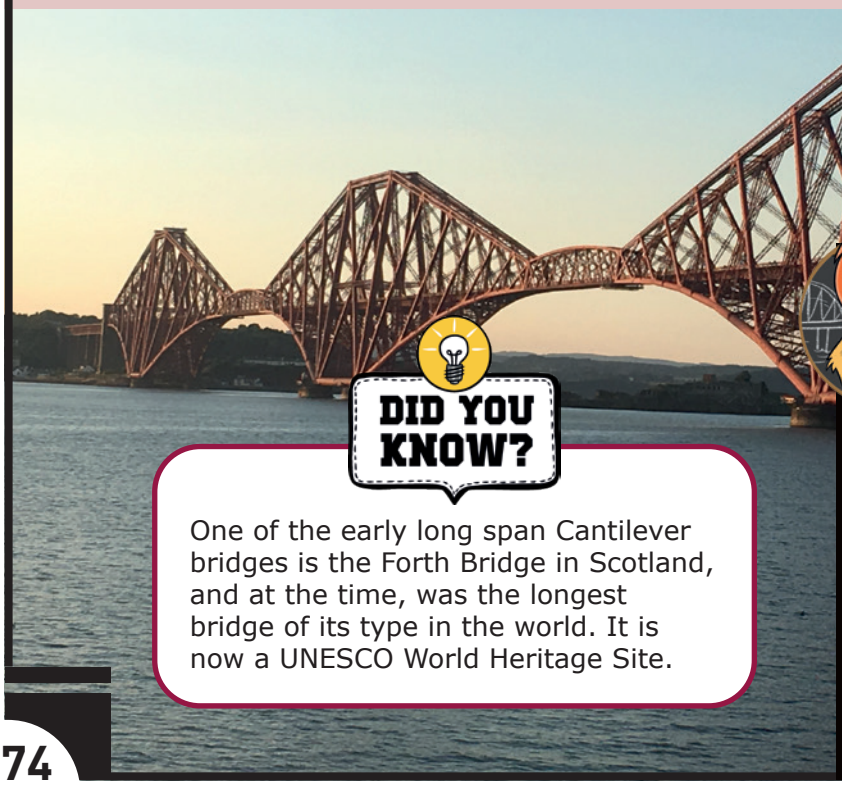
There are lots of examples of these machines if you search for 'Rube Goldberg machines for kids', and many videos showing them in action.

You could design your own 'Rube Goldberg machine' to turn on a light, turn off an alarm, or to water a plant, or if you see any online, you could build a 'chain reaction' type process using your toys.

Could you build a cantilever bridge using biscuits or flapjacks? How could you counterbalance them?

OUT & ABOUT

Can you spot any cantilevers? They don't have to be bridges, although we often use cantilever bridges for longer spans, as cantilevers can be found in all sorts of everyday objects! See how many you can find. Can you take a picture and explain how it works?



DID YOU KNOW?

One of the early long span Cantilever bridges is the Forth Bridge in Scotland, and at the time, was the longest bridge of its type in the world. It is now a UNESCO World Heritage Site.

Langdon presents:

- *Common structures* handout
- *Common structures* resource (PowerPoint)
- *Cantilever bridge terminology* handout
- *Cantilever bridge challenge* handout

Handouts can be found at www.rochesterbridgetrust.org.uk