




Chapter C: Truss Bridges – What is a Truss?

AIMS & OBJECTIVES

- To understand that triangles are the strongest shape for building bridges
- To explore truss bridges
- To learn the terminology for truss bridges

CONTEXT

Truss bridges are one of the oldest type of modern bridge and were widely used throughout the 19th century, especially for railway bridges. They are economical to construct because they make efficient use of materials. Initially they were made of timber but gradually iron and steel came to be used. It is relatively straightforward for engineers to calculate the forces in a truss bridge.



It can be difficult to design beam bridges that are strong enough to carry the weight of railway tracks and trains so engineers often use truss bridges.

LANGUAGE OF BRIDGES:

Abutment: the structure that the ends of the bridge rest on and can be anchored by.

Baltimore Truss: a type of truss bridge developed in the 1870s in Baltimore, USA. It is mainly used for railway bridges.

Beam: the simplest form of bridge, consisting of a single span resting on abutments.

Bowstring Truss: this was patented in 1841 by Squire Whipple. The Old Bridge at Rochester is a bowstring shaped truss.

Deck: the main surface of the bridge, the traffic crosses here.

Howe Truss: a type of truss bridge patented in 1840 by Millwright William Howe.

Parapet: a low wall or railing alongside the edge of the bridge deck to protect traffic from falling off.

Piers: the upright columns that support the bridge.

Pratt Truss: this is a bridge type found commonly in the USA, it was patented in 1844 by Thomas and Caleb Pratt.

Span: the distance between bridge supports.

Total span: the full distance, from one side to the other, the bridge covers.

Truss: a bridge designed with lots of triangle shapes.

Warren Truss: patented in 1848 by its designer James Warren.



You will need...

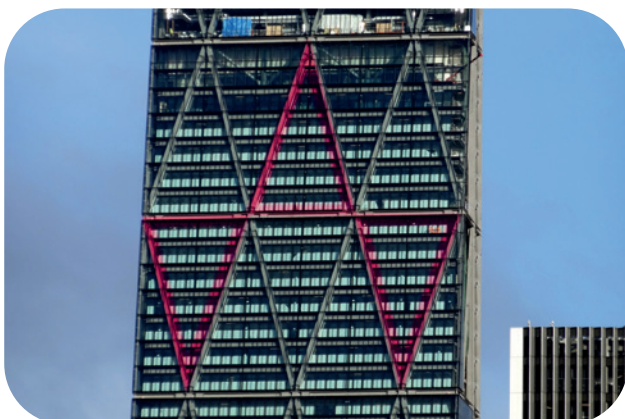
- Strong shapes, for each learner/pair:
 - 7 identical lengths of card with a hole punched in each end (30cm x 3cm)
 - 1 longer piece of card which will fit across the diagonal (43cm x 3cm)
 - 7 paper fasteners
- Exploring truss bridges, for each group:
 - K'Nex® Education Introduction to Structures – Bridges set
 - Handout: *Truss bridge terminology*
- Handout: *Describing truss bridges*
- Handout: *What is this truss?*
- Truss construction challenge, for each group:
 - Art straws (minimum 12 in total per group)
 - Washi (paper-based crafting) tape
 - Masses (such as coins or washers)
 - Handout: *Truss bridge challenge order form (optional)*



Something to Try:

How can shapes make a bridge strong?

Ask the learners if there are any similarities between the structures in the following images:

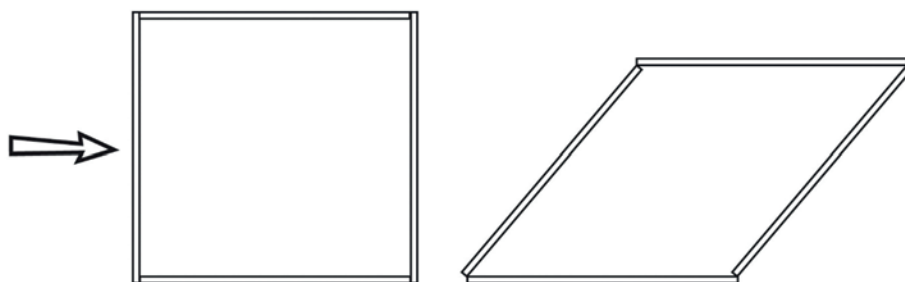


Photos courtesy of Guy Fox Limited

All of the structures include a combination of triangle shapes.

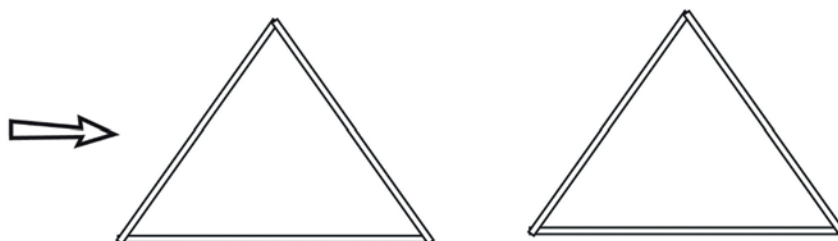


With learners working in pairs, if possible, make a square from four strips of card of the same length and some paper fasteners. When completed, ask learners to hold the square with one side resting on the table and test it by pushing and pulling on any side of it. They will see that the square immediately loses its shape and becomes a diamond. It is not a rigid shape.



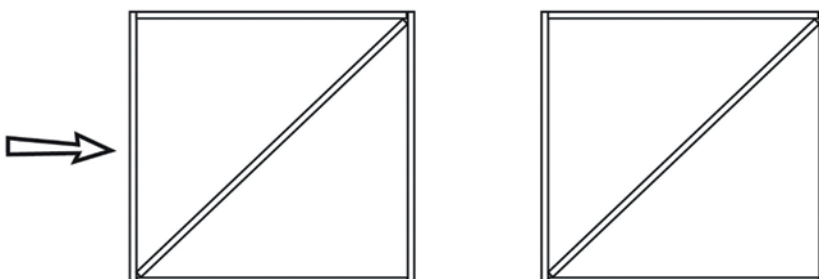
Next, ask learners to make a triangle (with equal sides) in the same way. When they push or pull the sides, they will see that the triangle holds its shape.

Triangles do not twist, bend or collapse easily in comparison with rectangles or other shapes. A triangle is the only shape that cannot be pushed or pulled out of shape without changing the length of one of the sides. This is because the load/force applied is distributed equally to all of the points, and the points cannot rotate: it is a rigid shape.



Ask learners how they could make the square stronger.

Encourage learners to add one strip of card across the diagonal of the square and fasten it with the paper fasteners. Again, test the shape to see how much stronger it has become by making it into two triangles.



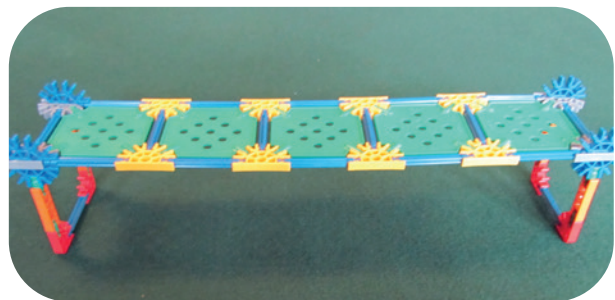
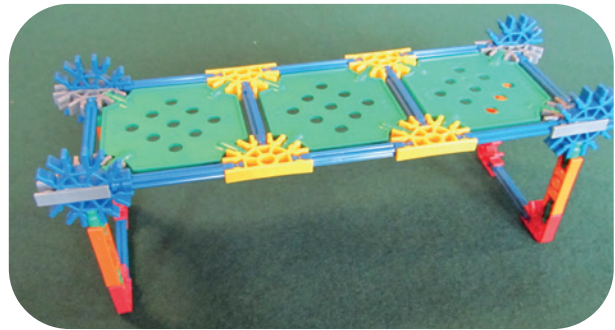


EXPLORING TRUSS BRIDGES

In small groups of 3 or 4, ask learners to construct a simple beam bridge using 3 deck slabs of K'Nex®.

Push gently on the centre and show that this is a strong structure.

Links to Learning About Bridges Chapter Bii: Beam Bridges – Simple but Strong



Extend each beam bridge to 5 deck slabs.

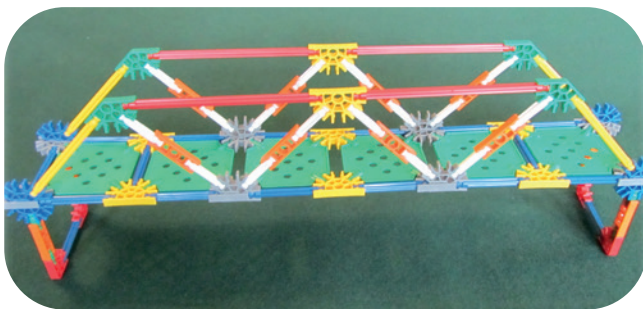
Again, push gently on the centre. Notice that the long bridge is much more bendy in the middle and not as strong as the short bridge.

Ask learners to consider the problems this might cause, and the limitations of beam bridges. The beam bridges are great for short distances, but what if you want to span a longer distance? As they get longer, beam bridges get weaker.

Ask learners how they might make the bridge stronger?

One way would be to make the deck thicker/to stiffen the deck. What would be the problem with doing this? It could make the deck very heavy and increase the load on the bridge.

Is there anything else we know that could increase the strength of a structure? What is the strongest shape? (Answer: the triangle.)



Hmmm... When I add a truss, I can make a much longer bridge!

A bridge made of triangles in this way is called a truss bridge. Use the 5 deck slab bridge and add triangles to build different models of truss.

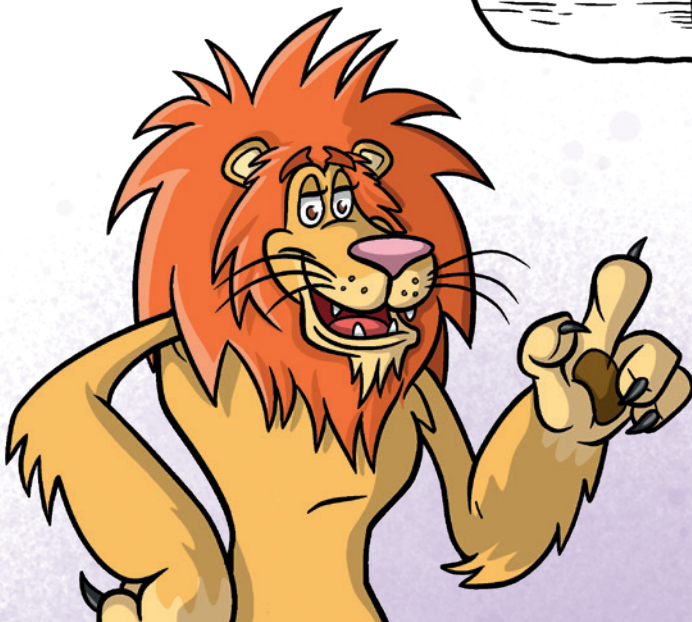
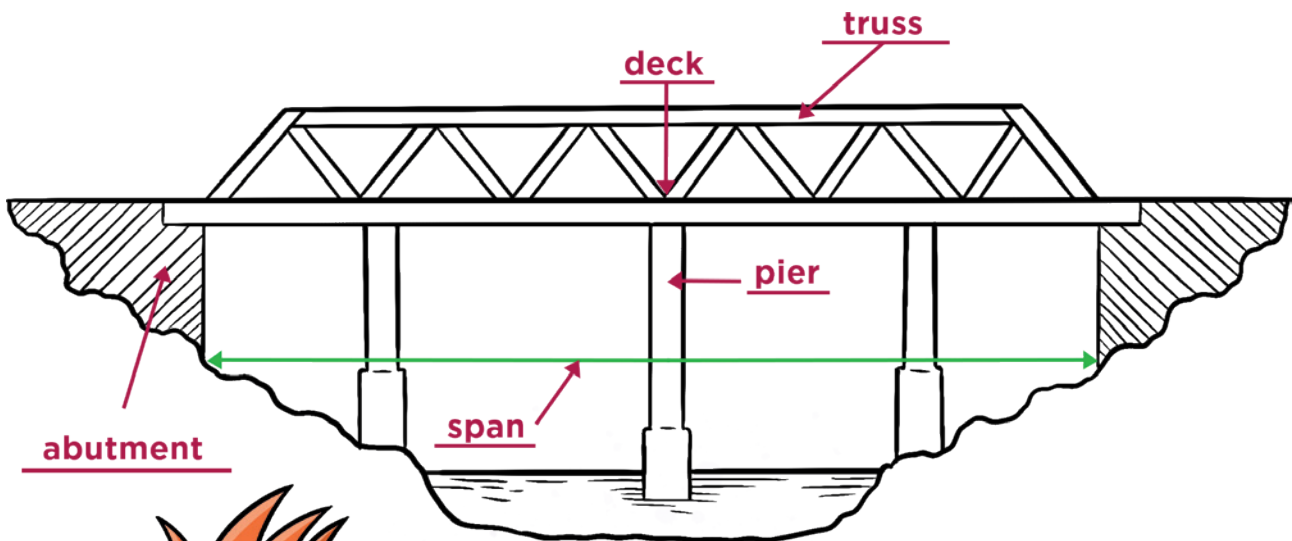
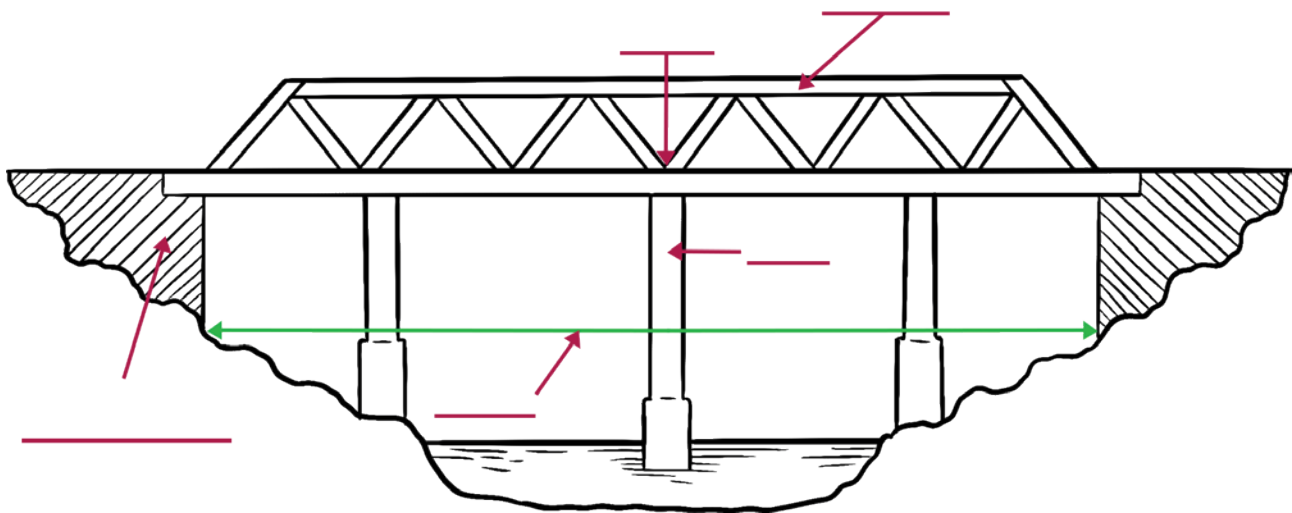
There are lots of different ways to arrange the triangles. Some ideas are provided in the K'Nex® kit, or you could experiment.





LABELLING THE TRUSS BRIDGE

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





TYPES OF TRUSS BRIDGE

Almost every combination of triangles was used in truss bridges from 1800 to 1900. The *Describing truss bridges* handout has lots of examples. Each design has a name, usually after the first person to design that shape, or the place where it was first tried or sometimes using a description of the shape itself. The way engineers describe a truss bridge is based on the arrangement of the parts of the truss.

Challenge learners to identify the type of truss used in some real bridges, using proper terminology, with the *What is this truss?* handout.

Answers:

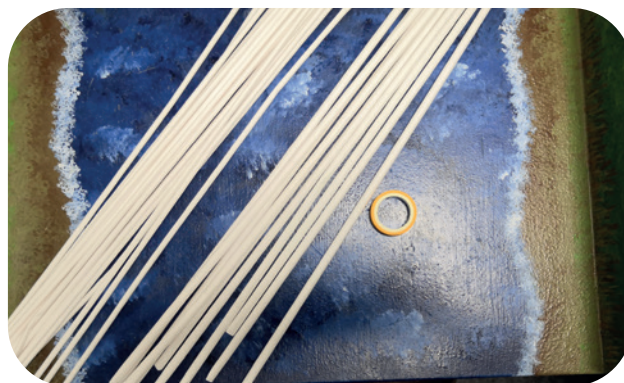
- A - Baltimore Truss
- B - Warren Truss
- C - Pratt Truss
- D - Warren Truss

Challenge Time!



TRUSS BRIDGE CONSTRUCTION

Give each group the art straws and Washi tape. Challenge them to build a bridge using one of the main truss types from the *Describing truss bridges* handout. The bridges can then be tested with the masses.

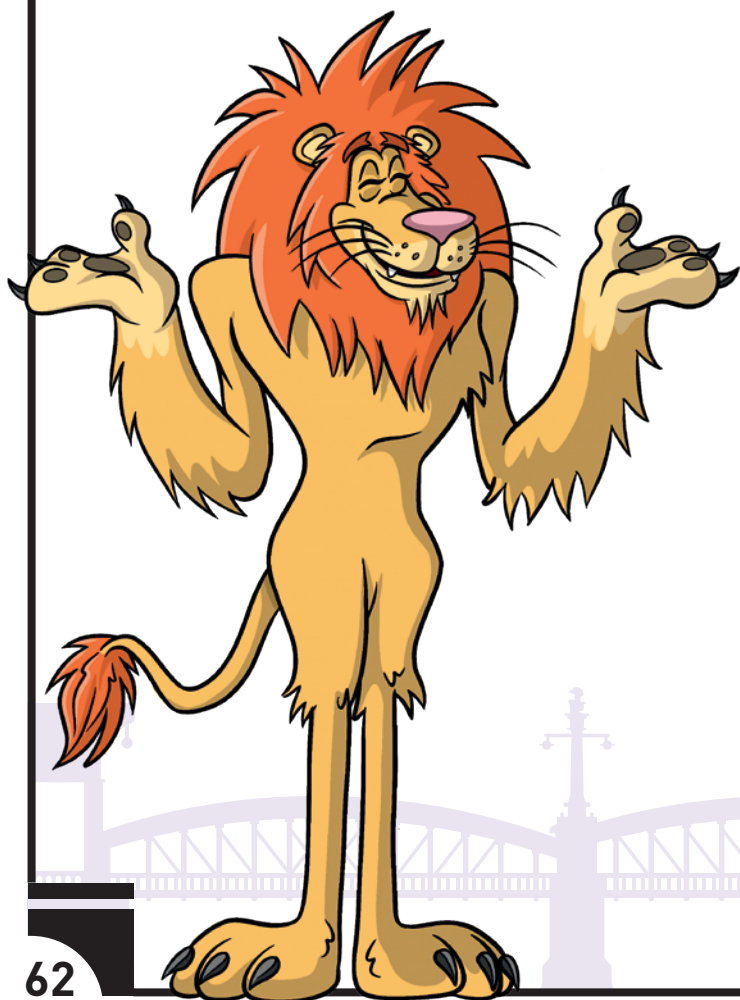


Your learners will need to think about how the loads and forces are distributed and how the trusses work.

For an additional challenge, you could set them a budget and create a materials price list for the paper straws and lengths of tape. They then need to think like an engineer and make sure they purchase sufficient materials to create a strong truss bridge, without going over their budget. You could use the *Truss bridge challenge order form* handout for this.



As your learners build, invite them to consider how they communicate their ideas using the correct scientific language. Help them to see that making observations about the way their structure behaves is developing scientific enquiry skills.





You could invite learners to build a truss bridge by gluing wooden lollipop sticks together to form equilateral triangles. Once the glue has fully dried, you can test the strength of the bridge using masses.

Triangles form a particular type of fractal called a Sierpinski Triangle. You could use this repeating pattern of triangles to build a tree. Search the internet for "How to make a Sierpinski Christmas Tree" to find out how.



HOT TOPICS!

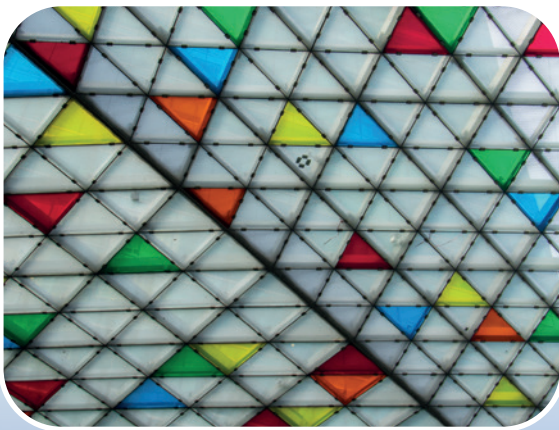


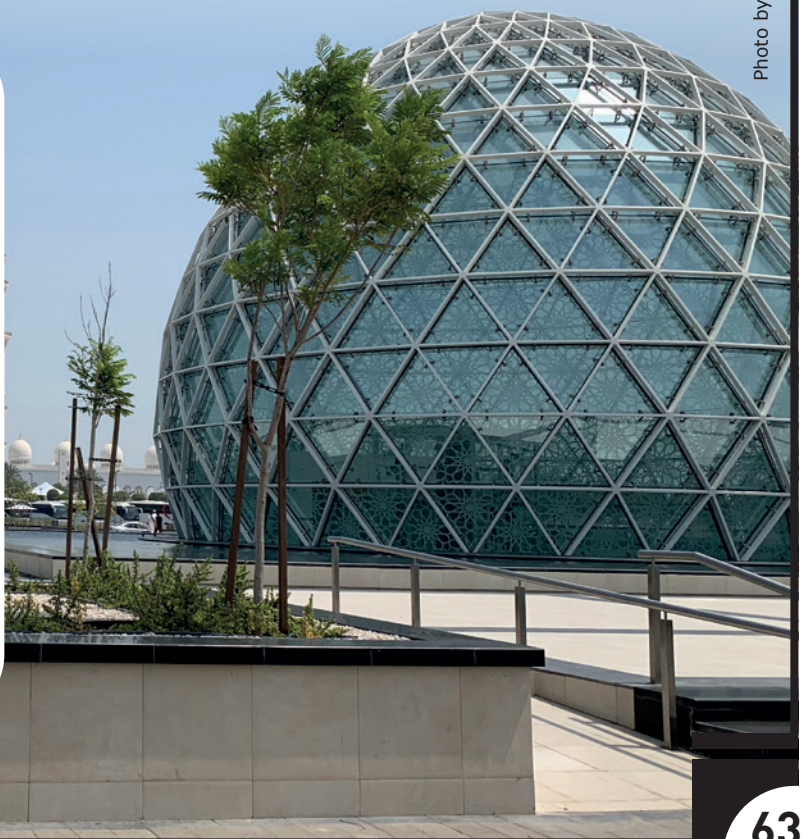
Photo by Nick Fewings on Unsplash

A tessellation (or tiling) is when a surface is covered with a pattern of flat shapes so there are no overlaps or gaps. Triangles are one of the few shapes that form a regular tessellation pattern (squares and hexagons are the others). Tessellation is found repeatedly in architecture. You could explore forming tessellations with different shape combinations, or instead be inspired by tessellations from great works of architecture, the art of MC Escher or in nature to create your own art.

Photo by Safdar-Hussain on Unsplash



Photo by Andrés Yves on Unsplash



HOT TOPICS!



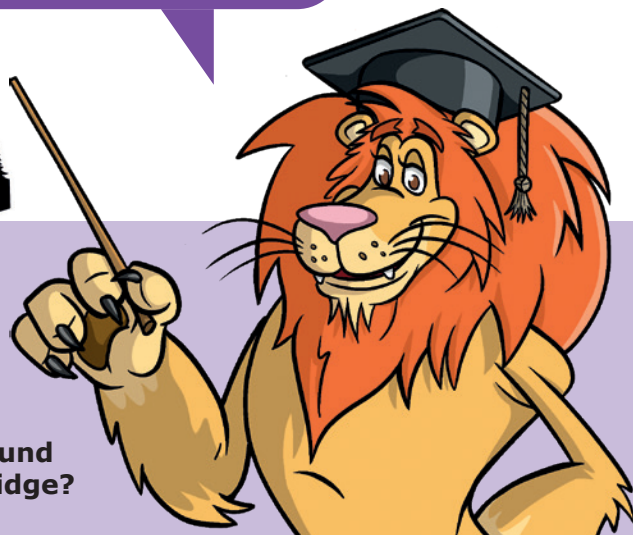
A geodesic dome is a combination of triangles to form a sphere – arches are parts of spheres and are strong shapes in bridges. You could explore geodesic domes and even build a model, either using toothpicks and marshmallows to form the triangles, or make triangles out of paper straws, before joining them together.

Once you start looking for truss bridges, it's surprising how many you'll see!



Try to spot a truss bridge in your local area. Take a photo (if it is safe to do so) and identify the parts using the correct terms. What type of truss bridge is it? What is the bridge used for?

If you can't find one locally, try looking on the internet to see if you can find truss bridges around the world. Can you identify the type of truss bridge?



DID YOU KNOW?

There is actually a truss bridge that doesn't have any triangles! Called a Vierendeel truss, it relies on having a very rigid frame instead of the diagonal bracing in the usual trusses.



Langdon presents:

- *Truss bridge terminology* handout
- *Describing truss bridges* handout
- *What is this truss* handout
- *Truss bridge challenge order form* handout

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

Vierendeel Truss (Photo by Ben Titze via Wikimedia)