Learning about: Buildings & Bridges

Triangular frames and arches

Cranes are used to lift enormous weights to great heights. They are made out of a steel frame which consists of many small triangular shapes. Have you ever wondered why are they built like this? Carry out the next experiment and find out why the triangular shape is so much preferred in structures!

Discover:

- Why triangulation is needed to strengthen structures?
- Which part of an arch requires support?

Level Of Difficulty ★★☆☆☆

Materials Needed:
- Engino® Buildings & Bridges (STEM06).

Procedure:

1. Using your Engino parts, build a small triangle and a square as in the next pictures.

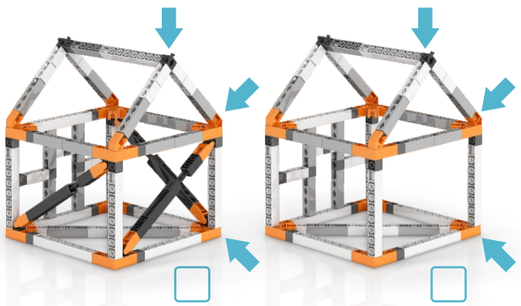
2. Push the sides and the corners in order to find out the strongest positions. Try to modify the square by adding some more parts in order to make it stronger and answer **exercises 1 and 2**.

3. Build an arch, as in the picture on the right and push it down. Complete **exercise 3.**

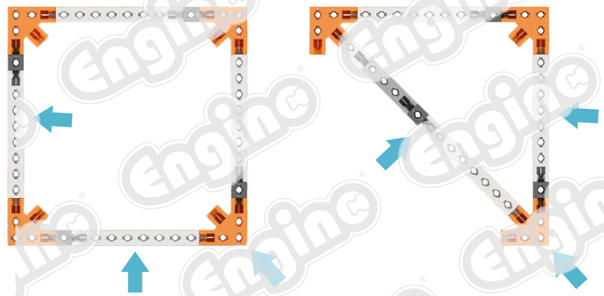
4. Find the instructions in **pages 19-20** and build the **house** model. Once it is finished, push its corners and sides. Compare the rigidity of the structure when you push from the corner supported by the diagonal extendable rod and when from the unsupported corner.

5. Remove the diagonals (extendable rods) from the walls of the house and test again. After complete **exercise 4**.

4 a. Compare the rigidity of the houses below and put a mark on the strongest one.

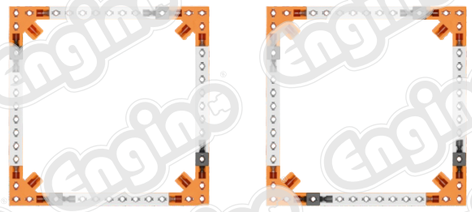


1. Push the sides and the corners of the shapes you built, as shown in the pictures below.



Which points are stronger? *The **corners** are stronger than the sides.*

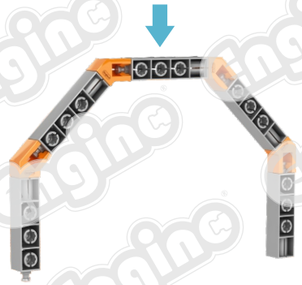
2. How can you modify the square in order to become stronger? Try out 2 solutions and show how you did it below.



3 a. Draw some arrows to show where the force is redirected.

3 b. How does the arch behave? What can you do to strengthen this shape?

*The arch's legs move **outwards**. To strengthen it, we could apply a resisting force (weights) to each leg or connect the legs together.*



4 b. What is the benefit of triangulation?

The triangle has the ability to transfer the force to its angles, which are stronger and therefore the whole structure becomes stronger too.

Learning about: Buildings & Bridges

Forces acting on structures

Which material do you think is stronger: paper or wood? Maybe you are thinking that paper can be teared easily so wood is stronger, but that is not entirely truth. Even if you apply the same force on the same body, sometimes the shape of the body plays a very important part on its rigidity.

Discover:

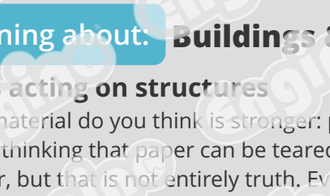
- Which are the different types of forces?
- How can a structure become stronger?

Level Of Difficulty ★★★☆☆

Materials Needed:
- Engino® Buildings & Bridges (STEM06).
- Some weight (e.g. books).
- 15 sheets of A4 photocopy paper.
- Glue or tape.

Procedure:

1. Take a piece of paper and hold it from the edges. What do you observe? Does it hold its shape or bend? How can you make it stronger? Roll the paper around a cylindrical surface, like your pencil, to create a hollow tube. Apply different types of forces shown in **exercise 1** and complete the table.



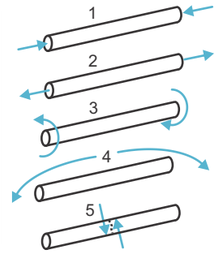
2. Build a **platform** (without the pillars) by following the instructions online of the **beam bridge** (look also at the picture in exercise 2).

3. Use four paper tubes to support the platform. Try 3 different shapes of paper (triangular, rectangular and cylindrical) to support it and test how much weight each shape can support. Complete **exercise 2**.

4. Build 3 types of sandwich panels using paper and glue (or tape). You should make 3 inner shapes: cylindrical, triangular and rectangular, as shown in the next pictures. Place them on the platform of the bridge and apply some weight to test how much the bridge can support. You can place books on the panels, one after the other and see how many books you can stack before the panels give in.

1. Complete the following table according to your observations. State whether the paper tube resists each type of force by writing **weak** or **strong**. Look carefully at the pictures on the right in order to understand how to apply each force.

	Force	Paper Tube
1.	Compression (push)	*strong*
2.	Tension (pull)	*strong*
3.	Torsion (twist)	*weak*
4.	Bending	*weak*
5.	Shear (tear)	*weak*



2. Try to create a strong bridge using engino parts and 4 sheets of paper. Try 3 different shapes of paper: triangular, rectangular and cylindrical.

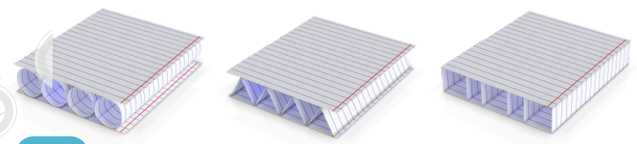
Which is the best paper shape used to support the maximum weight?

***Cylindrical** is the strongest shape. The triangular shape has less contact surface, so more pressure is applied and the rectangular shape does not distribute the load evenly like the cylindrical does.*

3. Can you identify the strongest sandwich type? Compare the strength of the paper panels and complete the table below by using the words **strong**, **medium** and **weak**. Provide a brief explanation of your observations.

paper sandwich	strength
cylindrical inner supports	*weak*
triangular inner supports	*strong*
square inner supports	*medium*

***Triangular supports** are stronger. They distribute the load better and are strong on compression.*



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