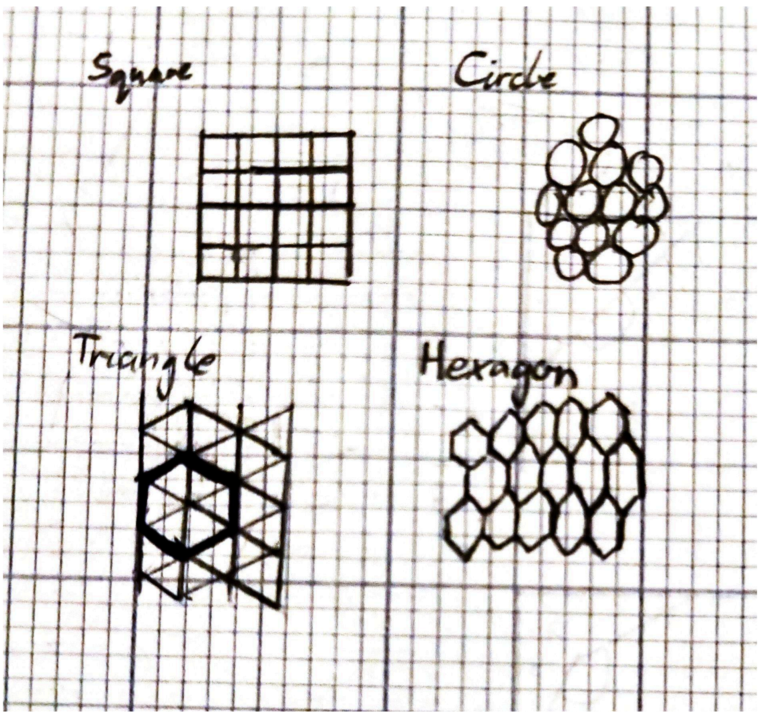
What is the strongest shape?

Introduction

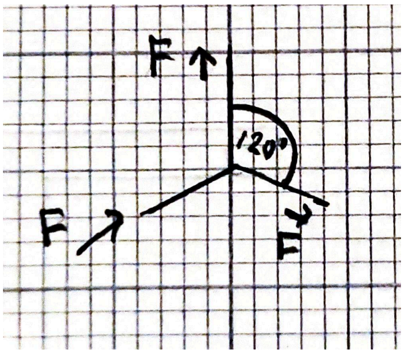
Shapes. We see them everywhere in all colours, sizes and well… shapes. Shapes can be smooth and rigid. Curved and flat. We use them everywhere and practically for everything, but have you ever wondered what was the strongest shape and what we could essentially do with its capabilities? What surface area, volume or length enables efficiency and strength? Let's find out.

Case Study 1: Hexagons

Weird shape to start with right? I thought so too, but then I thought… bees. Nature's engineers use hexagons to build their hives but why do they do so? Bees make honey and wax. Wax is used to build hives. 1 unit of wax would require 8 units of honey which would require 72 flowers. Wax is expensive for bees. What shape would enable the most efficient use of wax? A hexagon. In shape tiling, the hexagon is the only regular shape that when tiled does not conform to self division and leaves gaps and as a result makes it an extremely efficient shape for bees to use. Even other shape tilings tend to form a hexagonal shape as well.



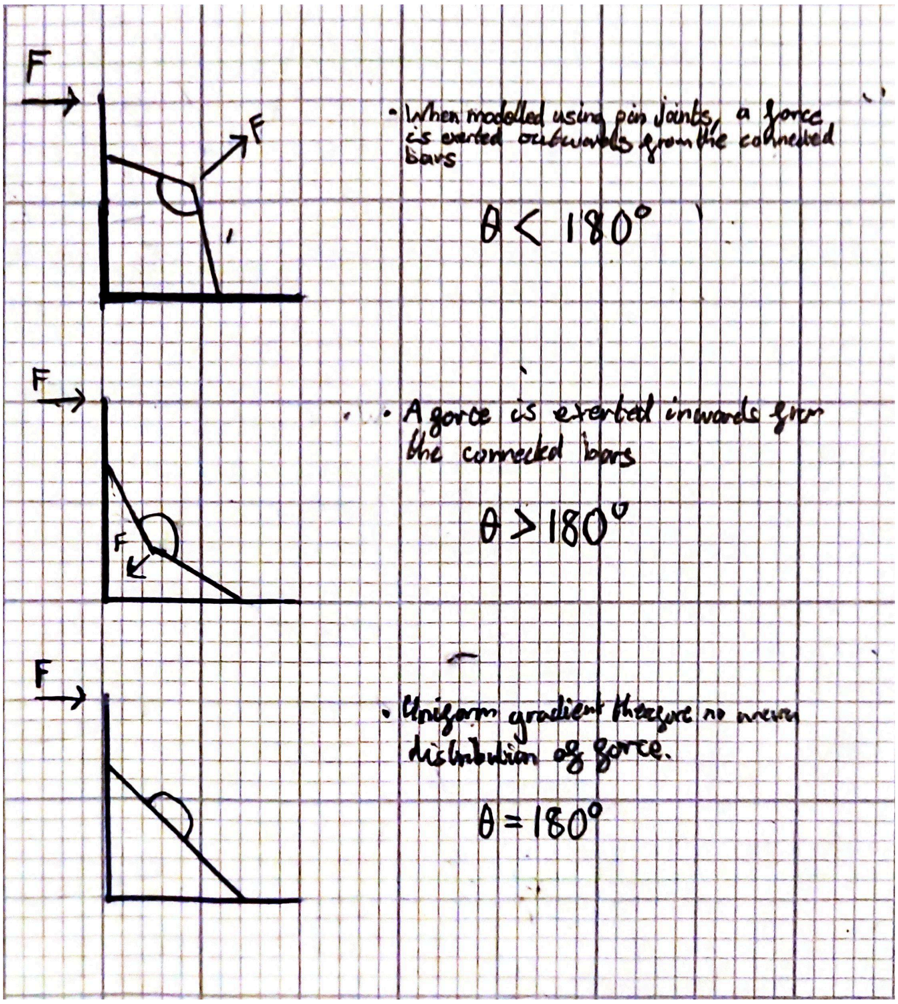
When hexagons are next to each other, they also distribute forces evenly amongst components.



Hence why when snowflakes form, atoms make a hexagonal shape to provide a strong stable structure. But not just snowflakes, almost all types of ice make a hexagonal structure. Graphene is a material made of graphite used in technology and has an ultimate tensile strength of 130000000000 Pascals. That's a lot of 0s. It would take an elephant balancing on a pencil to break a sheet of graphene as thin as paper. Graphene is made of carbon atoms bonded via covalent bonds in the form of hexagonal rings.

Case Study 2: Triangles

Model shapes with their sides as pieces of cardboards and their vertices held together by a pin so there is no resistance to rotational force. You'd find that all shapes fall apart as a result of the rotational forces on the joints except a triangle. The pin joints offer no resistance to the rotational force meaning all the forces are axial. Trusses(Network of triangles) are commonly used in cranes, bridges and transmission towers. Triangles distribute the applied force evenly across components. Another way to look at this is by thinking of two planks perpendicular to each other. If a force is applied to the plank perpendicular to the ground, the magnitude of force required to push the plank would be dependent on the structure connecting the two planks.

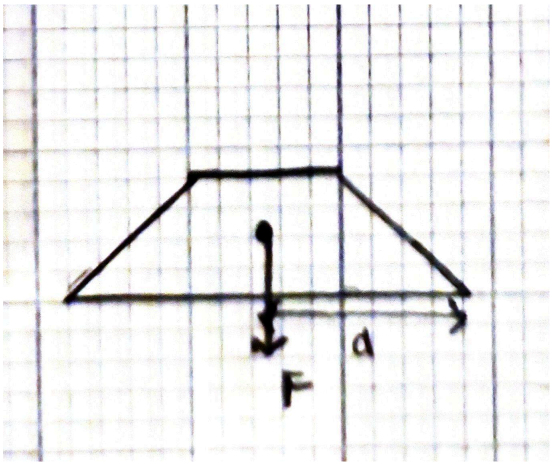


(This is known as a buttress)

Triangles enable rigidity in structures and essentially they could be labelled the “fundamental shape”. A shape with n sides will have (n-2) triangles in it excluding circles which have infinite triangles? Circles are made of an infinite amount of sectors which resemble triangles.

Case Study 3: Quadrilateral

Despite previous case studies, quadrilaterals can be extremely strong shapes. This is because having a flat base and a flat top means that the base can be manipulated so the shape remains stable. An object's stability relies on the position of its centre of mass. If it falls outside an object's base, it becomes unstable and falls. This is why you fall over when you lean forward too far. Quadrilaterals are commonly used in infrastructure and architecture as a result of their simplicity. Quadrilaterals such as trapeziums have a larger base making them more stable and harder to move as there is a larger distance from the vertex to the centre of mass.



3D Capabilities Introduction

Hexagons by far seem to be the strongest shape but with the logic that all shapes are made of triangles could it be argued that triangles are the strongest shape as to say it is any other shape is just to say that triangles arranged in such a way provides strength and rigidity. However, we don't live in a 2 Dimensional plane. So what 3D shape would provide rigidity for infrastructure, technologies and buildings? My answer; a lot of 3D shapes. This is because 3D shapes are an assortment of one or more types of 2D shapes put together. So theoretically the strongest 3D shape might have some the following qualities:

- Have lines which meet at 120 degrees
- Have lines which meet at 45 degrees
- Be a truss
- Conform to a hexagonal structure
- Have a small number of vertices

References:

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