YOUNG MASTER CHALLENGE

Little Bee Mathematics CONCEPT IN LIFE: Engineering

Article

Maths in Engineering: From Simple Machines to Mighty Pyramids

Hey Young Masters of Maths! 🧠 Ever wondered how giant skyscrapers stand so tall, or how a single person can lift a heavy car? The secret ingredient is a super-powered team-up of engineering and mathematics. This year, we're diving into how these two subjects worked together to create amazing things, from the simple tools in your home to the incredible pyramids of ancient Egypt.

Why Maths is an Engineer's Best Friend

So, what does an engineer do? An engineer is a problem-solver who designs and builds things, from a tiny computer chip to a massive bridge. And what's their most important tool? You guessed it – maths!

- Design and Measurement: Before building anything, engineers need a plan. They use geometry to design the shape and size of their creations and measurement to make sure everything fits together perfectly.
- Calculations and Predictions: Engineers use mathematical formulas to predict how their designs will work. They calculate things like force, pressure, and strength to make sure a bridge won't collapse or a plane can fly safely.
- Problem-Solving: When something goes wrong, engineers use their maths skills to figure out why and find a solution.

Throughout history, significant discoveries in mathematics have led to remarkable new inventions in engineering. The development of algebra helped engineers to create more complex designs, and the invention of calculus allowed for the building of even bigger and better structures. Without maths, the world of engineering would be a lot less exciting!

Simple Machines: Making Life Easier

What do a see-saw, a jar lid, and a flagpole have in common? They are all simple machines! A simple machine is a basic tool that makes work easier by changing the direction or amount of force needed to move an object. There are six main types:

1. Lever: A stiff bar that rests on a pivot point called a fulcrum. (e.g., a see-saw or a bottle opener)
2. Wheel and Axle: A wheel that turns on a rod called an axle. (e.g., a doorknob or a car's wheels)
3. Pulley: A wheel with a groove for a rope or cable. (e.g., a flagpole or a crane)
4. Inclined Plane: A flat, sloped surface. (e.g., a ramp or a slide)
5. Wedge: Two inclined planes put together to a sharp edge. (e.g., an axe or a knife)
6. Screw: An inclined plane wrapped around a cylinder. (e.g., a jar lid or a lightbulb)

The Maths Behind the Muscle

Simple machines give us a mechanical advantage, which means they multiply our effort. We can calculate this using ratios.

Mechanical Advantage (MA) = Output Force / Input Force

- Output Force: The force the machine applies to the object.
- Input Force: The force you apply to the machine.

Let's look at an example with a lever:

Imagine you want to lift a 100 kg rock (this is the output force). You use a long lever and find you only need to push down with the force of 10 kg (this is the input force).

MA = 100 kg / 10 kg = 10

Your lever has given you a mechanical advantage of 10! You're 10 times stronger!

Work is another important concept. In physics, Work = Force x Distance. Simple machines don't change the amount of work you do, but they make it feel easier by letting you use less force over a longer distance.

Example:

Imagine you need to lift a heavy box 1 meter high.

- Lifting it straight up: You need a lot of force, but you only move it 1 meter.
- Using a ramp (inclined plane): You need less force, but you have to push the box a longer distance up the ramp to reach the same height.

In both cases, you do the same amount of work, but the ramp makes it easier!

Building the Great Pyramids: An Ancient Engineering Marvel

The Great Pyramids of Egypt are one of the most remarkable engineering feats in history. Over 4,000 years ago, the Ancient Egyptians built the Great Pyramid of Giza. It was the tallest building in the world for over 3,800 years! Each stone block weighed up to 2,500 kg. For thousands of years, people have wondered how the ancient Egyptians built these massive structures without modern technology. The answer lies in their brilliant understanding of maths and engineering.

The secret: mathematics and simple machines.

- They used ramps (inclined planes) to drag stones upward.
- Levers and logs (wheels and axles) helped move blocks into place.
- They measured using cubits (about 52 cm long).
- They used geometry to make sure the base was a perfect square and the sides lined up at the right angles.

Maths in the Sand

The Egyptians were master mathematicians and used their skills in every step of pyramid building:

- Geometry and Angles: The pyramids have a perfect square base and four triangular sides that meet at a single point. The Egyptians used their knowledge of geometry to get the angles just right, ensuring the pyramid would be stable. The sides of the Great Pyramid, for example, rise at an angle of about 51.8 degrees.
- Measurement and Precision: The Egyptians had a standard unit of measurement called the cubit (about 52.3 cm). They used this to make sure the dimensions of the pyramid were incredibly accurate. The base of the Great Pyramid is almost a perfect square, with sides of about 230 meters, and the difference between the longest and shortest sides is only a few centimeters!
- Ratios and Proportions: The design of the pyramids is based on specific ratios and proportions, which some people believe were related to their understanding of astronomy and the Earth.

A few Ancient Maths Problem

Imagine you are an ancient Egyptian architect. You need to calculate the volume of a pyramid to know how many stone blocks you will need.

You know the formula for the volume of a pyramid is:

Volume = (1/3) * Base Area * Height

Problem: Your pyramid has a square base with sides of 100 cubits, and a height of 90 cubits. What is the volume of the pyramid?

Calculation:

1. Find the Base Area: Base Area = side * side = 100 cubits * 100 cubits = 10,000 square cubits
2. Calculate the Volume: Volume = (1/3) * 10,000 square cubits * 90 cubits
   Volume = (1/3) * 900,000 cubic cubits
   Volume = 300,000 cubic cubits

So, you would need enough stone blocks to fill a volume of about 300,000 cubic cubits!

Let's now measure the number of cubits used for the base.

If each side of the base were 230 m, the perimeter would be:

$230 \times 4 = 920$ m.

If they used cubits (≈0.50 m), the base length was:

$230 \div 0.50 \approx 460$ cubits.

Another example could be finding the Pyramid's Slope using our knowledge of angles.
The Great Pyramid is about 146 meters tall with a base of 230 meters.

- Half of the base = 115 meters.
- If you draw this as a triangle, the height is 146 m and the half-base is 115 m.

👉 How to find the slope angle without tricky maths:

1. On graph paper, draw a vertical line 14.6 cm tall (this stands for 146 m).
2. From the bottom of that line, draw a horizontal line 11.5 cm long (this stands for 115 m).
3. Connect the top of the vertical line to the end of the horizontal line — now you have a right-angled triangle like the side of the pyramid.
4. Place a protractor at the base corner and measure the angle where the ground meets the slope.

You'll find it is about 51°.
That's the slope the Egyptians used! By carefully measuring and keeping all four sides the same, they created an almost perfect pyramid.

Work Smarter, Not Harder with Ramps
Let's see how the ancient Egyptians made the impossible possible using simple machines.
Imagine a massive limestone block weighing 2,500 kg needs to be raised 1 meter onto the next level of a pyramid. If one strong worker can lift 25 kg, it would take 100 workers (2,500 kg ÷ 25 kg) to lift the block straight up. This would be incredibly crowded, dangerous, and difficult to coordinate.
Instead, the engineers used an inclined plane, or a ramp. If they built a ramp that was 10 meters long to raise the block by 1 meter, they cleverly made the job ten times easier.
Because the distance was 10 times longer, the force needed to pull the block was 10 times smaller. Now, the task only required 10 workers (100 workers ÷ 10) to pull the block up the ramp safely.
This demonstrates the scientific principle of Work, where Work = Force × Distance.

- Lifting directly: A huge force over a short distance.
- Using a ramp: A small force over a long distance.

The total amount of work done is the same, but using the ramp made the task manageable and allowed the Egyptians to build their incredible monuments.

Final Thought
From lifting rocks to building pyramids, maths has always been the engineer's best tool. Simple machines show us how ratios, force, and distance make work easier. The Egyptians proved that with careful measurement, angles, and geometry, humans can achieve wonders that last thousands of years.

By understanding the power of maths, you can see how engineers, both ancient and modern, have shaped our world. So, the next time you see a towering building or ride your bike (wheel & axle), walk up a ramp, or open a jar (screw), remember the amazing maths that made it all possible!

Good luck in the Young Master Challenge! 🏆