







# Material properties

## SECTION 1.1

Property	Definition	Example
Strength	The ability of a material to withstand force, three different types of force – Tension (material being pulled apart), Compression (material being push together compressed) and Torsion material being twisted. Yield strength = forced needed to start permanently deforming the material. Ultimate Yield strength = when the material fails.	
Ductility	The amount a material can be deformed into long thin wires or stands like synthetic fibres or copper wire.	
Malleability	The ability of a material to be deformed without rupturing, think of materials that can be easily moulded into various shaped like clay or bluetack.	
Hardness	The ability of a material to withstand scratching and abrasion and won't wear away easily. Think of stainless steel and how you use them everyday but they don't wear away.	
Toughness / Brittleness	The ability of a material to withstand an impact without breaking / shattering, think of a hammer when you strike a nail or the opposite when you drop a ceramic plate or a glass product.	
Stiffness	The ability of a material to resist bending like the beams that you stand on when on a second floor of a house. The beams can hold your weight without bending or moving.	

### Mathematical understanding – Stress

$$\text{Stress} = \frac{\text{Force}}{\text{Cross sectional area}}$$

Example layout of questions:

#### Stress

Force = (read through question)

Cross section area = (length x width) or use  $\pi \times R^2$ .

Then put number in the equation.

#### Strain

Original length = (read through question)

Change in length = extended length – original length

Then put numbers in equation

$$\text{Young's modulus, } E = \frac{\text{Stress}}{\text{Strain}}$$

#### Young's modulus

Combine the two layouts above to work out each bit.

# Material properties

## SECTION 1.1

What is meant by the term Strength?

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Below sketch the three different types of forces

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What is the difference between yield strength and ultimate tensile strength?

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Mathematical understanding – Stress

Calculate the yield stress of the following metals

Mathematical understanding – Stress

$$\text{Stress} = \frac{\text{Force}}{\text{Cross sectional area}}$$

- 1, A test piece had a square section with each side 10mm. The force applied when the material started to yield was 24,500 Newtons (show all working)
- 2, A test piece had a square section with each side 20mm. The force applied when the material started to yield was 20,000 Newtons (show all working)
- 3, A test piece had a square section with each side 35mm. The force applied when the material started to yield was 14,000 Newtons (show all working)
- 4, A test piece had a square section with each side 12mm. The force applied when the material started to yield was 12,750 Newtons (show all working)
- 5, A test piece had a square section with each side 35mm. The force applied when the material started to yield was 47,250 Newtons (show all working)

# Material properties

Give an example of product that demonstrates the strength property

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Explain how this product has high strength?

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Give an example of product that demonstrates the Ductility property

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Explain how this product has good Ductility?

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Give an example of product that demonstrates the Malleability property

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Explain how this product is malleable?

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Give an example of product that demonstrates the Harness property

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Explain how this product uses this property?

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Give an example of product that demonstrates the Toughness property

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Explain how this product uses toughness?

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# Material properties

## SECTION 1.1

Calculate the yield stress of the following metals

$$\text{Strain} = \frac{\text{Change in length}}{\text{Original length}}$$

1, when there is no load the bar is 1.55m long. When the load is applied the bar extends to a length of 2.25m. (show all workings)

2, when there is no load the bar is 1.15m long. When the load is applied the bar extends to a length of 1.65m. (show all workings)

3, when there is no load the bar is 3.4m long. When the load is applied the bar extends to a length of 3.45m. (show all workings)

Calculate the **Young's modulus** of the following metals

$$\text{Young's modulus, } E = \frac{\text{Stress}}{\text{Strain}}$$

1, A tensile test was carried out on a ceramic test piece. The test piece was square section 35mm x 35mm

At the point when the force was 160kN, the strain in the test piece was calculated to be  $1.4 \times 10^{-3}$

Calculate the Young's modulus of the material.

(show all workings)

2, A tensile test was carried out on a ceramic test piece. The test piece was rectangular in section 60mm x 25mm

At the point when the force was 285kN, the strain in the test piece was calculated to be  $1.5 \times 10^{-3}$

Calculate the Young's modulus of the material.

(show all workings)