MATHEMATICAL SKILLS

MATHS IN ENGINEERING
SUPPLEMENTARY BOOK ONE

YIELD STRESS
STRAIN
YOUNG'S MODULUS

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REVISION AND UNDERSTANDING
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YIELD STRESS - MATHEMATIC APPLICATION

FORMULA

$$\sigma = F/A$$

$$\text{STRESS} = \frac{\text{FORCE}}{\text{AREA}}$$

1. A sample of steel (from an engineering company) is given a stress test to assess its <u>yield stress</u>.

The steel is a 20mm square section. The sample begins to yield at 30 000 Newtons.

What is the yield stress?

$$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$$

$$\sigma = \frac{F}{A}$$

$$\text{STRESS} = \frac{30\ 000\ \text{N}}{20\ \text{mm} \times 20\ \text{mm}}$$

$$\text{STRESS} = \frac{30\ 000}{400\text{mm}^2}$$

$$\text{STRESS} = 75\ \text{N/mm}^2$$

2. A second sample of steel (from the same engineering company), is given a stress test to assess its <u>yield stress</u>.

The steel is a 40mm square section. The sample begins to yield at 40 000 Newtons.

What is the yield stress?

$$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$$

$$\sigma = \frac{F}{A}$$

$$\text{STRESS} = \frac{40\ 000\ \text{N}}{40\ \text{mm} \times 40\ \text{mm}}$$

$$\text{STRESS} = \frac{40\ 000}{1600\text{mm}^2}$$

$$\text{STRESS} = 25\ \text{N/mm}^2$$

YIELD STRESS - MATHEMATIC APPLICATION - QUESTIONS

FORMULA

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$$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$$

$$\sigma = \frac{F}{A}$$

YIELD STRESS - MATHEMATIC APPLICATION

FORMULA

$$\sigma = F/A$$

$$\text{STRESS} = \frac{\text{FORCE}}{\text{AREA}}$$

3. A civil engineer, designing a bridge, has submitted a sample of steel to your materials testing facility. It is to be given a stress test to establish its yield stress.

The steel is a 50mm square section. The sample begins to yield at 50 000 Newtons.

What is the yield stress?

$$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$$

$$\sigma = \frac{F}{A}$$

$$\text{STRESS} = \frac{50\ 000\ \text{N}}{50\ \text{mm} \times 50\ \text{mm}}$$

$$\text{STRESS} = \frac{50\ 000}{500\text{mm}^2}$$

$$\text{STRESS} = 100\ \text{N/mm}^2$$

4. A model engineer, is making a component for a model steam train. He has submitted a sample of brass to your materials testing facility. It is to be given a stress test to establish its yield stress.

The steel is a 8mm square section. The sample begins to yield at 1000 Newtons.

What is the yield stress?

$$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$$

$$\sigma = \frac{F}{A}$$

$$\text{STRESS} = \frac{1000\ \text{N}}{8\ \text{mm} \times 8\ \text{mm}}$$

$$\text{STRESS} = \frac{1000}{64\text{mm}^2}$$

$$\text{STRESS} = 15.63\ \text{N/mm}^2$$

<u>YIELD STRESS - MATHEMATIC APPLICATION - QUESTIONS</u>

<u>FORMULA</u>

$$\sigma = F/A$$

$$\text{STRESS} = \frac{\text{FORCE}}{\text{AREA}}$$

3. A civil engineer, designing a bridge, has submitted a sample of steel to your materials testing facility. It is to be given a stress test to establish its <u>yield stress</u>.

The steel is a 50mm square section. The sample begins to yield at 50 000 Newtons.

What is the yield stress?

$$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$$

$$\sigma = \frac{F}{A}$$

4. A model engineer, is making a component for a model steam train. He has submitted a sample of brass to your materials testing facility. It is to be given a stress test to establish its <u>yield stress</u>.

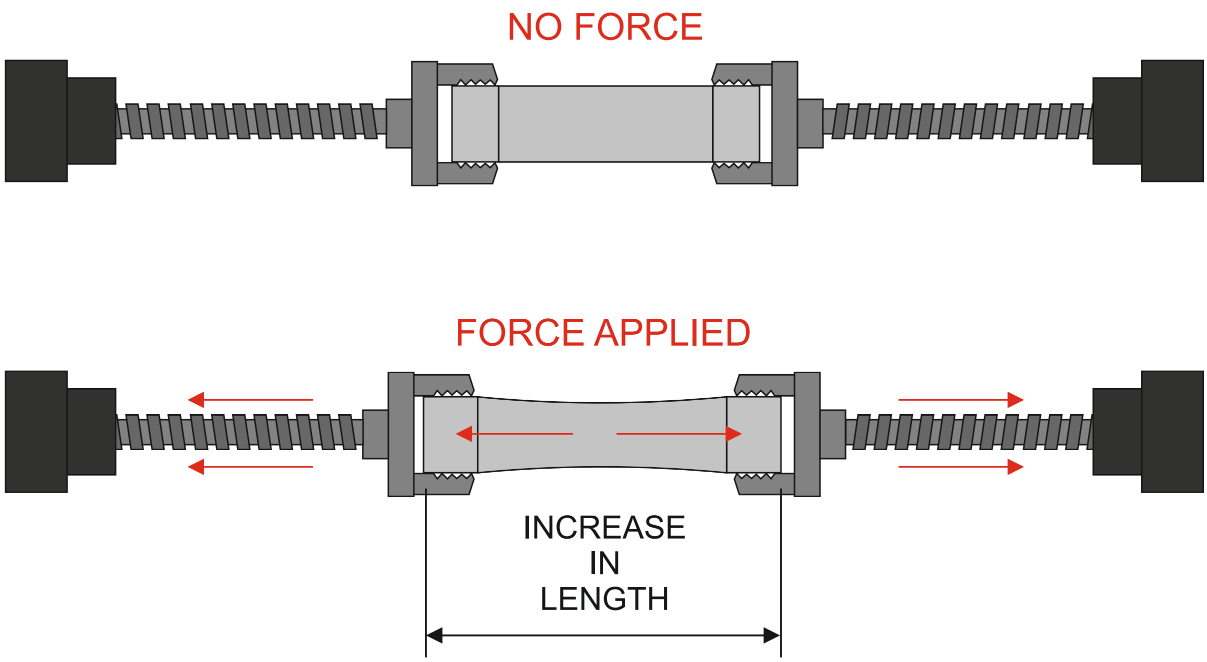
The steel is a 8mm square section. The sample begins to yield at 1000 Newtons.

What is the yield stress?

$$\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}$$

$$\sigma = \frac{F}{A}$$

STRAIN



FORMULA

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

The sample metal (above) being tested, is 200mm in length when no force is applied (no load). However, when force / a load is applied it stretches to a length of 210mm. What is the ‘strain’.

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

$$\varepsilon = \frac{210\text{mm} - 200\text{mm}}{200\text{mm}}$$

$$\varepsilon = \frac{10\text{mm}}{200\text{mm}}$$

$$\varepsilon = 0.05 \text{ or } 5.0 \times 10^{-2}$$

STRAIN - MATHEMATIC APPLICATION - QUESTIONS

FORMULA

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

1. An Engineers Research Company has submitted a sample for strain testing, to your materials testing facility. The sample metal being tested, is 500mm in length when no force is applied (no load). However, when force / a load is applied it stretches to a length of 520mm. What is the 'strain'.

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

$$\varepsilon = \frac{520\text{mm} - 500\text{mm}}{500 \text{ mm}}$$

$$\varepsilon = \frac{20\text{mm}}{500\text{mm}}$$

$$\varepsilon = 0.04 \text{ or } 4.0 \times 10^{-2}$$

2. The Engineers Research Company has submitted a second sample for strain testing. The sample metal being tested, is 800mm in length when no force is applied (no load). However, when force / a load is applied it stretches to a length of 840mm. What is the 'strain'.

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

$$\varepsilon = \frac{840\text{mm} - 800\text{mm}}{800\text{mm}}$$

$$\varepsilon = \frac{40\text{mm}}{800\text{mm}}$$

$$\varepsilon = 0.05 \text{ or } 5 \times 10^{-2}$$

STRAIN - MATHEMATIC APPLICATION - QUESTIONS

FORMULA

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

1. An Engineers Research Company has submitted a sample for strain testing, to your materials testing facility. The sample metal being tested, is 500mm in length when no force is applied (no load). However, when force / a load is applied it stretches to a length of 520mm. What is the 'strain'.

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

2. The Engineers Research Company has submitted a second sample for strain testing. The sample metal being tested, is 800mm in length when no force is applied (no load). However, when force / a load is applied it stretches to a length of 840mm. What is the 'strain'.

$$\text{STRAIN } (\varepsilon) = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}$$

YOUNG’S MODULUS

Young’s Modulus, is the direct relationship between the ‘stress’ and ‘strain’ of a material (the ratio of ‘stress’ to ‘strain’). It is shown by the formula below and measures the ‘stiffness’ of a solid material.

$$\text{Young's Modulus } (E) = \frac{\text{stress } (\sigma)}{\text{strain } (\varepsilon)}$$

CALCULATING YOUNG'S MODULUS

1. A cylindrical test piece of nylon has been sent to your Materials Testing Laboratory. You have been asked to calculate the Young's Modulus of the test piece.

Radius = 25mm   Force applied = 200 kN and strain at this point = 3.1×10^{-4}

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{CROSS SECTION AREA} = \pi r^2$$

<u>FIRST</u> CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

$$\text{CROSS SECTION AREA} = \pi r^2$$

Pi (π) = 3.14

RADIUS = 25mm

CROSS SECTION AREA = 3.14 X (25 X 25)

CROSS SECTION AREA = 3.14 X 625

CROSS SECTION AREA = 1962.5 mm^2

<u>THEN</u> CALCULATE THE STRESS OF THE TEST PIECE

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

FORCE = 200kN

$$\text{STRESS } (\sigma) = \frac{200}{1962.5}$$

STRESS (σ) = 0.102 kN/mm^2

<u>NOW YOU CAN</u> CALCULATE YOUNG'S MODULUS OF THE TEST PIECE

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

Strain at this point = 3.1×10^{-4}

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{YOUNG'S MODULUS (E)} = \frac{0.102}{3.1 \times 10^{-4}}$$

$$= \frac{0.102}{0.00031}$$

$= 329 kN/mm^2$

CALCULATING YOUNG'S MODULUS - QUESTION

1. A cylindrical test piece of nylon has been sent to your Materials Testing Laboratory. You have been asked to calculate the Young's Modulus of the test piece.

Radius = 25mm   Force applied = 200 kN and strain at this point = 3.1×10^{-4}

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{CROSS SECTION AREA} = \pi r^2$$

FIRST CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

$$\text{CROSS SECTION AREA} = \pi r^2$$

Pi (π) = 3.14

RADIUS = 25mm

CROSS SECTION AREA =

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THEN CALCULATE THE STRESS OF THE TEST PIECE

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

FORCE = 200kN

STRESS (σ) = ________

STRESS (σ) =

NOW YOU CAN CALCULATE YOUNG'S MODULUS OF THE TEST PIECE

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

Strain at this point = 3.1×10^{-4}

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

YOUNG'S MODULUS (E) = ________

= ________

=

CALCULATING YOUNG'S MODULUS

2. An automobile company has sent a sample of steel, to your Materials Testing Laboratory. You have been asked to calculate the Young's Modulus of the test piece.

Radius = 15mm   Force applied = 150 kN and strain at this point = 4.1×10^{-4}

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{CROSS SECTION AREA} = \pi r^2$$

FIRST CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

$$\text{CROSS SECTION AREA} = \pi r^2$$

Pi (π) = 3.14

RADIUS = 25mm

$$\text{CROSS SECTION AREA} = 3.14 \times (15 \times 15)$$

$$\text{CROSS SECTION AREA} = 3.14 \times 225$$

$$\text{CROSS SECTION AREA} = 706.5 \text{ mm}^2$$

THEN CALCULATE THE STRESS OF THE TEST PIECE

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

FORCE = 150kN

$$\text{STRESS } (\sigma) = \frac{150}{706.5}$$

$$\text{STRESS } (\sigma) = 0.212 \text{ kN/mm}^2$$

NOW YOU CAN CALCULATE YOUNG'S MODULUS OF THE TEST PIECE

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

Strain at this point = 4.1×10^{-4}

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{YOUNG'S MODULUS (E)} = \frac{0.212}{4.1 \times 10^{-4}}$$

$$= \frac{0.212}{0.00041}$$

$$= 517.07 \text{ kN/mm}^2$$

CALCULATING YOUNG'S MODULUS

2. An automobile company has sent a sample of steel, to your Materials Testing Laboratory. You have been asked to calculate the Young's Modulus of the test piece.

Radius = 15mm Force applied = 150 kN and strain at this point = 4.1×10^{-4}

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

$$\text{CROSS SECTION AREA} = \pi r^2$$

FIRST CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

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Pi (π) = 3.14

RADIUS = 25mm

CROSS SECTION AREA =

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CROSS SECTION AREA =

THEN CALCULATE THE STRESS OF THE TEST PIECE

$$\text{STRESS } (\sigma) = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}$$

FORCE = 150kN

STRESS (σ) = ________

STRESS (σ) =

NOW YOU CAN CALCULATE YOUNG'S MODULUS OF THE TEST PIECE

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

Strain at this point = 4.1×10^{-4}

$$\text{YOUNG'S MODULUS (E)} = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}$$

YOUNG'S MODULUS (E) = ________

= ________

=