YIELD STRESS
STRAIN
YOUNG’S MODULUS

FOR ALL YOUR ENGINEER
REVISION AND UNDERSTANDING
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YIELD STRESS - MATHEMATIC APPLICATION

FORMULA

\[ \sigma = \frac{F}{A} \]

STRESS = \( \frac{FORCE}{AREA} \)

1. A sample of steel (from an engineering company) is given a stress test to assess its yield stress. The steel is a 20mm square section. The sample begins to yield at 30 000 Newtons. What is the yield stress?

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

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

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

2. A second sample of steel (from the same engineering company), is given a stress test to assess its yield stress. The steel is a 40mm square section. The sample begins to yield at 40 000 Newtons. What is the yield stress?

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

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

\[ \text{STRESS} = 25 \text{ N/mm}^2 \]
1. A sample of steel (from an engineering company) is given a stress test to assess its yield stress. The steel is a 20mm square section. The sample begins to yield at 30 000 Newtons. What is the yield stress?

\[
\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}
\]

\[
\sigma = \frac{F}{A}
\]

2. A second sample of steel (from the same engineering company), is given a stress test to assess its yield stress. The steel is a 40mm square section. The sample begins to yield at 40 000 Newtons. What is the yield stress?

\[
\text{STRESS} = \frac{\text{FORCE}}{\text{SECTION AREA}}
\]

\[
\sigma = \frac{F}{A}
\]
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?

\[
\text{STRESS} = \frac{F}{A}
\]

\[
\sigma = \frac{50\ 000}{500\text{mm}^2}
\]

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

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?

\[
\text{STRESS} = \frac{F}{A}
\]

\[
\sigma = \frac{1000}{64\text{mm}^2}
\]

\[
\text{STRESS} = 15.63\ N/\text{mm}^2
\]
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?

\[
\sigma = \frac{F}{A}
\]

STRESS = FORCE
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 yield stress. The steel is a 8mm square section. The sample begins to yield at 1000 Newtons. What is the yield stress?

\[
\sigma = \frac{F}{A}
\]

STRESS = FORCE
SECTION AREA

\[
\sigma = \frac{F}{A}
\]
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'.

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

\[
\varepsilon = \frac{210\text{mm} - 200\text{mm}}{200\text{mm}} = \frac{10\text{mm}}{200\text{mm}} = 0.05 \text{ or } 5.0 \times 10^{-2}
\]
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'.

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

\[
\varepsilon = \frac{520 \text{mm} - 500 \text{mm}}{500 \text{mm}} = \frac{20 \text{mm}}{500 \text{mm}} = 0.04 \text{ or } 4.0 \times 10^{-2}
\]

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'.

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

\[
\varepsilon = \frac{860 \text{mm} - 800 \text{mm}}{800 \text{mm}} = \frac{60 \text{mm}}{800 \text{mm}} = 0.075 \text{ or } 7.5 \times 10^{-2}
\]
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’.

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

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’.

\[
\text{STRAIN (}\varepsilon\text{)} = \frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}}
\]
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.

\[
\text{Young's Modulus (E)} = \frac{\text{stress (}\sigma\text{)}}{\text{strain (}\varepsilon\text{)}}
\]
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 = $3.1 \times 10^{-4}$

<table>
<thead>
<tr>
<th>STRESS ($\sigma$)</th>
<th>$= \frac{FORCE (F)}{CROSS SECTION AREA (A)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>YOUNG’S MODULUS ($E$)</td>
<td>$= \frac{STRESS (\sigma)}{STRAIN (\epsilon)}$</td>
</tr>
</tbody>
</table>

CROSS SECTION AREA $= \pi r^2$

FIRST CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

<table>
<thead>
<tr>
<th>CROSS SECTION AREA</th>
<th>$= \pi r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pi ($\pi$)</td>
<td>$= 3.14$</td>
</tr>
<tr>
<td>RADIUS</td>
<td>$= 25$ mm</td>
</tr>
</tbody>
</table>

CROSS SECTION AREA $= 3.14 \times (25 \times 25)$

CROSS SECTION AREA $= 3.14 \times 625$

CROSS SECTION AREA $= 1962.5$ mm$^2$

THEN CALCULATE THE STRESS OF THE TEST PIECE

<table>
<thead>
<tr>
<th>STRESS ($\sigma$)</th>
<th>$= \frac{FORCE (F)}{CROSS SECTION AREA (A)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORCE</td>
<td>$= 200$ kN</td>
</tr>
</tbody>
</table>

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

STRESS ($\sigma$) $= 0.102$ kN/mm$^2$

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

<table>
<thead>
<tr>
<th>YOUNG’S MODULUS ($E$)</th>
<th>$= \frac{STRESS \ (\sigma)}{STRAIN \ (\epsilon)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strain at this point</td>
<td>$= 3.1 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

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

YOUNG’S MODULUS ($E$) $= \frac{0.102}{0.00031}$

YOUNG’S MODULUS ($E$) $= 329$ 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 \times 10^{-4}

**First Calculate Cross-Sectional Area of the Test Piece**

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

\[
\pi (\pi) = 3.14
\]

\[
\text{RADIUS} = 25\text{mm}
\]

**Then Calculate the Stress of the Test Piece**

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

\[
\text{FORCE} = 200\text{kN}
\]

**Now You Can Calculate Young’s Modulus of the Test Piece**

\[
\text{YOUNG’S MODULUS} (E) = \frac{\text{STRESS} (\sigma)}{\text{STRAIN} (\varepsilon)}
\]

\[
\text{Strain at this point} = 3.1 \times 10^{-4}
\]
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 = $4.1 \times 10^{-4}$

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

\[
\text{YOUNG’S MODULUS } (E) = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}
\]

FIRST CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

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

\[
\text{Pi (}\pi\text{) } = 3.14
\]

\[
\text{RADIUS } = 25\text{mm}
\]

\[
\text{CROSS SECTION AREA } = 3.14 \times (15 \times 15) = 706.5 \text{ mm}^2
\]

THEN CALCULATE THE STRESS OF THE TEST PIECE

\[
\text{STRESS } (\sigma) = \frac{\text{FORCE}}{\text{CROSS SECTION AREA}}
\]

\[
\text{FORCE } = 150\text{kN}
\]

\[
\text{STRESS } (\sigma) = \frac{150}{706.5} = 0.212 \text{ kN/mm}^2
\]

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

\[
\text{STRAIN } (\varepsilon) = 4.1 \times 10^{-4}
\]

\[
\text{YOUNG’S MODULUS } (E) = \frac{\text{STRESS } (\sigma)}{\text{STRAIN } (\varepsilon)}
\]

\[
\text{YOUNG’S MODULUS } (E) = \frac{0.212}{4.1 \times 10^{-4}} = \frac{0.212}{0.00041} = 517.07 \text{ kN/mm}^2
\]
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 = \(4.1 \times 10^{-4}\)

\[
\text{STRESS (}\sigma\text{)} = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}, \quad \text{STRESS (}\sigma\text{)} = \frac{\text{STRESS (}\sigma\text{)}}{\text{STRAIN (}\varepsilon\text{)}}
\]

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

FIRST CALCULATE CROSS-SECTIONAL AREA OF THE TEST PIECE

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

\[
\text{Pi (}\pi\text{)} = 3.14
\]

\[
\text{RADIUS} = 25\text{mm}
\]

THEN CALCULATE THE STRESS OF THE TEST PIECE

\[
\text{STRESS (}\sigma\text{)} = \frac{\text{FORCE (F)}}{\text{CROSS SECTION AREA (A)}}, \quad \text{STRESS (}\sigma\text{)} = ______
\]

\[
\text{FORCE} = 150\text{kN}
\]

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

\[
\text{STRAIN (}\varepsilon\text{)} = \frac{\text{STRESS (}\sigma\text{)}}{\text{STRAIN (}\varepsilon\text{)}}, \quad \text{STRAIN (}\varepsilon\text{)} = ______
\]

\[
\text{Strain at this point} = 4.1 \times 10^{-4}
\]

\[
\text{STRAIN (}\varepsilon\text{)} = ______
\]

\[
\text{STRAIN (}\varepsilon\text{)} = ______
\]