**Skill Sheet: Stress, Strain and Young’s Modulus** **(for Engineering)**

***What You Need to Know:***

Testing the strength of a material normally involves applying a force to a test piece and measuring how its length changes. To allow different sizes of test piece to be compared, this load and extension must be converted into values for stress and strain:

***Examiners***

***Top Tip***

*Remember: the yield strength is the point where the stress-strain graph first stops being a straight line*

Yield

strength

Stress, σ = force / cross sectional area = F / A

Strain = change in length / length = δl / l

Young’s modulus is an indication of the stiffness of a material. It is the slope of the stress/strain graph obtained when testing the material:

Young’s modulus E = stress / strain = σ / ε

The value of stress used must be equal to or below the yield stress. Using a value below the yield stress does not change the value calculated for Young’s Modulus, as the corresponding strain will also be lower.

***Example:***

A tensile test was carried out on a test piece with a radius of 6 mm.

The force applied when the material started to yield was 463.7 kN.

***Examiners***

***Top Tip***

*Remember the formulae for areas:*

*For a rectangle = L x W*

*For a circle = π r2*

1. Calculate the yield strength of the material.
2. The strain at the yield strength was 0.02.

Calculate the Young’s modulus of the material.

***Answer:***

1. Cross-sectional area A = π r2 = π x 36 = 113.1 mm2

Stress σ = F / A = 463.7 / 113.1 = 4.1 kN mm-2

1. Young’s modulus E = σ / ε = 4.1 / 0.02 = 205 kN mm-2

***Now Try These:***

1. A load applied to a metal test piece causes it to extend from 50 mm to 51.5 mm. Calculate the strain in the test piece.

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1. A polymer has a Youngs modulus of 8 x 103 N mm-2 and a yield strength of 200 N mm-2.

Calculate the strain in the material when the applied load is equal to its yield strength.

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**Practice Sheet: Stress, Strain and Young’s Modulus (for Engineering)**

***Now Try These:***

1. A square-section test piece is being used in a tensile test.

The width and breadth of the test piece are each 15 mm.

Calculate the stress in the test piece when a load of 3150 N is applied.

**Figure 1**

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1. A round bar is 300 mm long. When a stress of 900 N mm-2 was applied, the length of the material increased to 304.5 mm. The bar returned to its original length when the stress was removed.

Calculate the Young’s Modulus of the material from which the bar is made.

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1. A tensile test was carried out on a cylindrical test piece with a radius of 5 mm and a length of 90 mm. The results are shown in figure 2. Calculate the Young’s modulus of the material.

**Figure 2**

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**Answers:**

**Skill Sheet: Stress, Strain and Young’s modulus**

1. Strain = δl / l = (51.5 – 50) / 50 = 0.03
2. Rearranging E = σ / ε, ε = σ / E = 200 / 8000 = 0.025

**Practice Sheet: Stress, Strain and Young’s modulus**

1. Area = 15 x 15 = 225 mm2

Stress = 3150 / 225 = 14 N mm-2

1. Strain, ε = change in length / original length = (304.5 – 300) / 300 = 0.015 (or 1.5 x 10-2)

Young’s modulus E = σ / ε = 900 / 0.015 = 60 kN mm-2

1. Area = π r2 = 3.14 x 25 = 78.5 mm2

Stress = load / area = 73 / 78.5 = 0.93 kN mm-2

Strain = δl / l = 1.5 / 90 = 0.017

Young’s modulus E = σ / ε = 0.93 / 0.017 = 54.7 kN mm-2

(allow 5% variation due to reading graph; other corresponding values of stress and strain can be used, but the value of the Young’s modulus should still be the same).