**Introduction Worksheet Answer Key**

**Theory, definitions, calculations for a stress test**

**Theory:** Stress testing of soft materials is conducted to understand how they respond to applied forces. This is essential for various applications, including medical devices, elastomers, and construction materials. The tests assess the material's elasticity, strength, and overall behavior under loads, providing valuable insights into its durability and performance in real-world conditions.

**Definitions**

**Stress (σ)**: The force applied per unit area, measured in Pascals (Pa) or Newtons per square meter (N/m²).

**Weight (W)**: The force exerted by gravity on an object, calculated as mass (in kilograms) multiplied by the acceleration due to gravity (9.8 m/s²), measured in Newtons (N).

**Stretch Ratio (λ)**: The ratio of the change in length to the original length of a material.

**Cross-Sectional Area (A)**: The area of a shape observed when cutting through an object perpendicular to its length, like slicing a loaf of bread.

**Stress-Stretch Curves**: Graphs that illustrate the elastic properties of a material by showing its stress response (force per area) as it stretches (deformation) under an applied force.

**Calculations for a stress test**

The following steps are used to find the stress corresponding to the applied force, cross-sectional area, and the change in length of a soft material.

1. Calculate stress.
   1. Stress (σ) is defined as the force (F) divided by the cross-sectional area (A).
   2. Formula: σ = F / A
2. Calculate the stretch ratio.
   1. The stretch ratio (λ) is the ratio of the change in length (ΔL) to the original length (L).
   2. Formula: λ = (L + ΔL) / L where λ is the stretch ratio, L is the original length of the material, and ΔL is the change in length.

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**Practice problem:** A soft material sample with a length of 15 centimeters and a cross-sectional area of 1.5 square centimeters is subjected to a tensile force of 20 Newtons and stretches 2 cm. Calculate the stress experienced by the material and the stretch ratio it undergoes.

Given:

Length (L) = 15 centimeters (cm); Cross-sectional area (A) = 1.5 square centimeters (cm2); Force (F) = 20 Newtons (N)

Step 1: Calculate stress. σ = F / A; σ = 20 N / 1.5 cm2 ; σ = 13.33 N/cm^2 (or 13,330 Pascals)

Step 2: Calculate stretch ratio. If ΔL = 2 centimeters, then

λ = (L + ΔL) / L, λ = (15 cm + 2 cm) / 15 cm λ = 1.133

The above calculation concludes that the soft material sample experiences a stress of 13,330 Pascals and undergoes a stretch ratio of 1.133 when subjected to a tensile force of 20 Newtons.

**Answer the following questions.**

1. Stress is defined as the force divided by the area over which it is applied.
2. The unit of force unit is Newton.
3. The stretch ratio is defined as Stretch, λ = (L + ΔL) / L
4. An experiment is conducted on rubber strings. The table below shows the new length (L) when masses are added. Complete the table by finding the weight, stress and stretch. Note: Cross-sectional area = 1.5 cm²

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mass**  **(kg)** | **Weight**  **(N)** | **Length**  **(cm)** | **Stress**  **(N/cm2)** | **Stretch**  **(λ)** |
| 0.1 | 0.98 | 2.0 | 0.65 | 1 |
| 0.2 | 1.96 | 2.1 | 1.31 | 1.05 |
| 0.3 | 2.94 | 2.6 | 1.96 | 1.3 |
| 0.4 | 3.92 | 2.9 | 2.61 | 1.45 |
| 0.5 | 4.9 | 3.4 | 3.2 | 1.6 |
| 0.6 | 5.88 | 4.4 | 3.92 | 1.96 |
| 0.7 | 6.86 | 4.5 | 4.57 | 2.29 |
| 0.8 | 7.84 | 5 | 5.23 | 2.62 |
| 0.9 | 8.82 | 5.3 | 5.88 | 2.94 |
| 1.0 | 9.8 | 5.6 | 6.5 | 3.25 |

1. Using Excel, plot a graph of stress vs. stretch and find the slope, Add labels, title, and units to the graphs. Attach your graph to this worksheet.