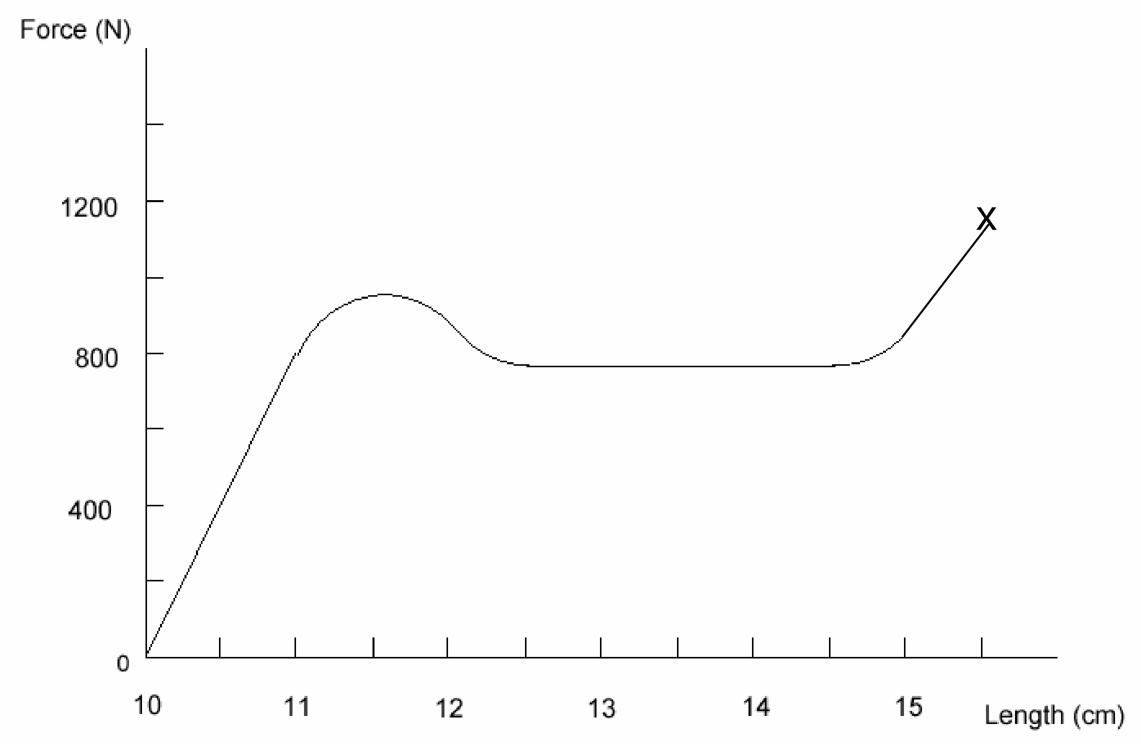
In-Class Exercise
Stress Strain Diagrams
SOLUTION

The graph below gives a plot of force versus total sample length in a tensile test. The sample is cylindrical, with an initial diameter of 1 cm and an initial length of 10 cm.

a. What type of material is this likely to be?
b. From the data above, calculate the modulus, yield stress, yield strain, tensile strength, and %elongation.



a) This is the typical behavior for a polymer.
b) The data is given in force vs. length, which can easily be converted to stress and strain.

Modulus

This is the slope of the initial linear region. One point on the linear region is at 0 N and 10cm, and another point is at 400 N and 10.5 cm. Converting these to stress and strain:

$$\sigma_1 = \frac{F_1}{A_0} = \frac{0\ \mathrm{N}}{\pi(0.005\ \mathrm{m})^2} = 0\ \mathrm{Pa}$$

$$\varepsilon_1 = \frac{L_1 - L_0}{L_0} = \frac{10\ \mathrm{cm} - 10\ \mathrm{cm}}{10\ \mathrm{cm}} = 0$$

$$\sigma_2 = \frac{F_2}{A_0} = \frac{400\ \mathrm{N}}{\pi(0.005\ \mathrm{m})^2} = 5.09\mathrm{x}10^6\ \mathrm{Pa}$$

$$\varepsilon_1 = \frac{L_1 - L_0}{L_0} = \frac{10.5\ \mathrm{cm} - 10\ \mathrm{cm}}{10\ \mathrm{cm}} = 0.05$$

$$E = \frac{\sigma_2 - \sigma_1}{\varepsilon_2 - \varepsilon_1} = 1.02\mathrm{x}10^8\ \mathrm{Pa} = 101.8\ \mathrm{MPa}$$

<u>Yield stress and strain</u>

For a polymer, the yield point is defined as the peak, where necking begins:

$$\sigma_y = \frac{950\ \mathrm{N}}{\pi(0.005\ \mathrm{m})^2} = 12.1\ \mathrm{MPa}$$

$$\varepsilon_y = \frac{11.6\ \mathrm{cm} - 10\ \mathrm{cm}}{10\ \mathrm{cm}} = 0.16$$

<u>Tensile strength</u>

The tensile strength is the stress at break. Therefore:

$$TS = \frac{1200\ \mathrm{N}}{\pi(0.005\ \mathrm{m})^2} = 15.3\ \mathrm{MPa}$$

<u>%Elongation</u>

This is the strain at break x 100:

$$\%EL = \frac{15.5\ \mathrm{cm} - 10\ \mathrm{cm}}{10\ \mathrm{cm}}\ \mathrm{x}100 = 55\%$$