Materials

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$$\text{density, } p = \frac{\text{mass, m}}{\text{volume, v}} \text{ unit: kg m}^{-3}$$

- **Hooke's law** states extension of a stretched object ∝ force

$$F = k\Delta l$$

  - This only applies up to the elastic limit, after which the material will be permanently stretched.
  - his plastic deformation results in a non-zero intercept on a F-Δl graph, but the gradient of such a graph remains the same as the forces between bonds are identical.

$$\text{for springs in parallel, effective } k = k_1 + k_2 \ldots + k_n$$

$$\text{for springs in series, } \frac{1}{\text{effective k}} = \frac{1}{k_1} + \frac{1}{k_2} \ldots \frac{1}{k_n}$$

- Elastic - returns to original shape and size when force is removed
- Plastic - material is permanently stretched

Stress and strain

$$\text{stress} = \frac{F}{A} \text{ unit: Pa N m}^{-2}$$

$$\text{strain} = \frac{\Delta l}{l} \text{ (no units)}$$

Elastic strain energy is the area below a force-extension graph.

$$\text{Elastic strain energy, } E = \frac{1}{2}F\Delta l = \frac{1}{2}k\Delta l^2$$

The **Young modulus** is a property of a material - it measures stiffness.

$$\text{Young modulus, } E = \frac{\text{stress}}{\text{strain}} = \frac{Fl}{A\Delta l} \text{ unit: Pa, N m}^{-2}$$

- The gradient of a stress—strain graph is thus equal to the Young modulus.
- Looking at a stress-strain graph, there are three key points: the limit of proportionality, after which the relationship is no longer linear, the elastic limit, past which plastic deformation occurs, and the yield point - after this point, the material suddenly starts to stretch without extra load.
- The stress-strain graph of a **brittle** material has no curve - it just stops.
- To measure the Young modulus, we need a long thin wire of the material - record the extension and the weight applied, and plot a graph. The graph can then be converted to stress-strain, or as the gradient is $\frac{\Delta l}{F}$, $\frac{1}{\text{gradient}} \times \frac{1}{A}$ = Young modulus