

## Deformation of solids

Q-1) What are the mechanical properties of solids?

> There are 4 mechanical properties of solids.

- ① **Stiffness** ; how easy it is to change shape
- ② **Strength** ; max load it can withstand before breaking
- ③ **Ductility** ; drawn into wires
- ④ **Toughness** ; related to brittleness

↳ a tough material is a one that is not brittle.

\* steel has all these properties

\* glass is only strong & STIFF.

Q-2) What is elasticity?

> Elasticity is when a force is applied, the body changes dimensions and when the force is removed, it returns to its original dimensions and no permanent change occurs.

Q-3) Stress?

> Stress is the force applied per unit area.

$$\text{Stress} \left( \frac{\text{N}}{\text{m}^2} \right) = \frac{\text{Force (N)}}{\text{area of cross section (m}^2\text{)}} \rightarrow \frac{F}{A}$$

**Longitudinal stress** (change in length)

$$= \frac{mg}{\text{area}} \quad (\text{mass} \times \text{gravity}) \text{ or } (\text{force}).$$

**Volume stress** (change in volume)

$$= dp \quad (\text{little change in pressure} \rightarrow p = \frac{F}{a})$$

**Shear stress** (change in shape without change in volume)

$$= \frac{\text{Force}}{\text{Area}}$$

Q-4) Strain?

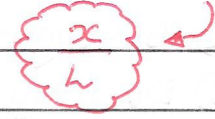
> Strain is the ratio of change in dimension to the original dimension.

$$\text{Strain} = \frac{\text{change (original - new)}}{\text{original}} \quad \text{extension} / \text{original}$$

↳ no units

Longitudinal Strain

$$\frac{\Delta \text{Length}}{\text{original length}} \quad \left( \frac{l}{L} \right)$$



Volume Strain

$$\frac{\Delta \text{volume}}{\text{original volume}} \quad \left( \frac{dv}{V} \right)$$

Shear Strain

lateral displacement of any layer  
 distance of that layer from a fixed layer.

Q-5) What is Hooke's law?

> Stress is proportional to strain within elastic limits. or  
 Force is proportional to extension.

$$F = kx$$

gradient / constant

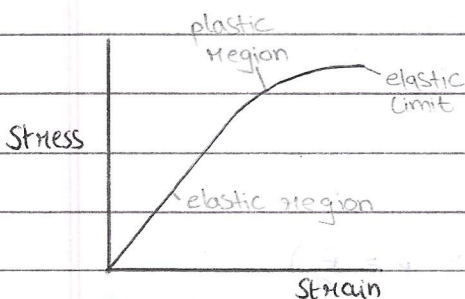
∴ less the extension

The higher the value of k, the stiffer the spring.

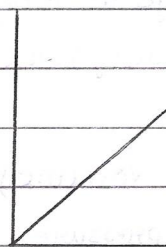
stress = constant (modulus of elasticity)

strain

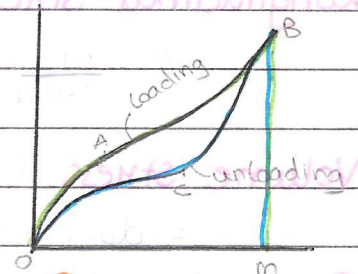
↳ units = N/m<sup>2</sup>



Ductile



Brittle



Polymer

OABM = energy supplied

OCBM = energy released

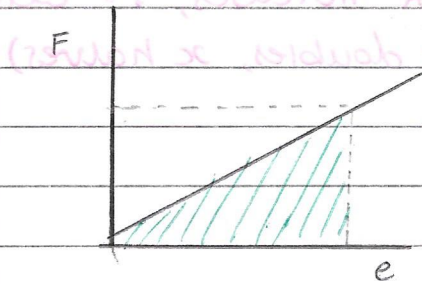
A resilient material is one that

has less hysteresis loss. ↳ energy lost = OABM - OCBM

↳ hysteresis loss



Q-6) Strain energy



work done = strain energy

$$W = \frac{1}{2} \times F \times e \quad \text{- area under graph (triangle)}$$

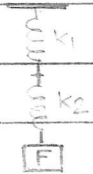
$$\text{strain energy per unit volume (E)} = \frac{\frac{1}{2} \times F \times e}{\text{volume}} = \frac{\frac{1}{2} \times F \times e}{\text{area} \times \text{length}}$$

$$E = \frac{1}{2} \times \frac{F}{A} \times \frac{e}{L} = \frac{1}{2} \times \text{stress} \times \text{strain}$$

Q-7) Spring constants

Series

When a force (F) is applied to a spring, extension is produced (x)



$$F \propto x \quad \text{or} \quad F = kx \quad \therefore k = F/x$$

$$\text{units} = \text{N/m} \quad \text{or} \quad \text{kgms}^{-2}$$

gradient of  $F \uparrow x \rightarrow$  graph = spring constant k.

$$x_1 = \frac{F}{k_1} \quad x_2 = \frac{F}{k_2}$$

$$x = x_1 + x_2 = \frac{F}{k_1} + \frac{F}{k_2} = F \left( \frac{1}{k_1} + \frac{1}{k_2} \right)$$

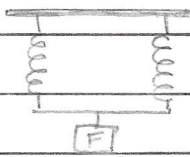
$$x = F \left[ \frac{k_1 + k_2}{k_1 k_2} \right]$$

Spring constant k in series decreases,  $\therefore$  extension increases.

$$F = x \left[ \frac{k_1 k_2}{k_1 + k_2} \right]$$

(k halves, extension doubles)

## Parallel



In parallel,  $k$  increases,  $\therefore$  extension decreases ( $k$  doubles,  $x$  halves)

$$F_1 = k_1 x \quad F_2 = k_2 x$$

$$F = F_1 + F_2 = k_1 x + k_2 x$$

$$F = x(k_1 + k_2)$$

Q-8) What is pressure?

> Pressure is the force acting per unit cross sectional area.

$$P = \frac{F}{A} \quad \rightarrow \quad F = mg$$

$$m = v \times \rho$$

$$v = A \times h$$

$$\therefore F = A \times h \times \rho \times g$$

$$\therefore P = \frac{A \times h \times \rho \times g}{A}$$

$$P = \rho \times g \times h$$

(k halves, extension doubles)