

Al-Mustaqbal University Colleg  
Medical Physics Department



# General Physics/ lecture 5

First stage

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# Lecture 5

## Outline

- Material properties.
- Density.
- Elasticity.
- Hooke's law.

## Properties of materials

- (a) *Physical properties* (density, specific heat, melting and boiling point, thermal expansion and conductivity, electrical and magnetic properties).
- (b) *Mechanical properties of materials* (strength, toughness, hardness, ductility, elasticity, fatigue and creep).
- (c) *Chemical properties* (Oxidation, corrosion, flammability, toxicity, etc.)

## Density

- ✓ Density is *mass per unit volume*. الكثافة هي كتلة وحدة الحجم

$$\text{Density} = \rho = \text{mass/volume}$$

- ✓ Typical units are:  $\text{Kg/m}^3$ ,  $\text{g/cm}^3$
- ✓ Relative density, or specific gravity *is the density of a material relative to density of water and is a ratio with no units.*

$$\text{Specific gravity} = \frac{\text{Density of the object}}{\text{Density of water}} = \frac{\rho_{\text{object}}}{\rho_{\text{H}_2\text{O}}}$$

## + Example (1)

A 250 cm<sup>3</sup> bottle of oil has a net mass of 189 g. Calculate the density and relative density of the oil and state whether the oil will float or sink in water?

**Solution:**

Mass,  $m = 189 \text{ g}$

Volume,  $V = 250 \text{ cm}^3$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\rho = \frac{m}{V}$$

$$\rho = \frac{189 \text{ g}}{250 \text{ cm}^3}$$

$$\therefore \rho = 0.756 \text{ g/cm}^3$$

$$\text{Relative Density} = \frac{\text{Density of Oil}}{\text{Density of Water}}$$

$$\text{Relative Density} = \frac{0.756 \text{ g/cm}^3}{1 \text{ g/cm}^3}$$

$$\text{Relative Density} = 0.756$$

Since,  $0 < \text{Relative Density} < 1$ ; the oil will float in water.

### **Example (2)**

A mechanical pencil has a density of 3 grams per cubic centimeter. The volume of the pencil is 15.8 cubic centimeters. What is the mass of the pencil in kilo grams?

**Solution:**

Density,  $\rho = 3 \text{ g/cm}^3$

Volume,  $V = 15.8 \text{ cm}^3$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Mass} = \text{Density} \times \text{Volume}$$

$$m = \rho \times V$$

$$m = 3 \text{ g/cm}^3 \times 15.8 \text{ cm}^3$$

$$m = 47.4 \text{ g}$$

Convert 47.4 g to kg

$$1 \text{ 000 g} = 1 \text{ kg}$$

$$1 \text{ g} = \frac{1}{1 \text{ 000}} \text{ kg}$$

$$47.4 \times 1 \text{ g} = 47.4 \times \frac{1}{1 \text{ 000}} \text{ kg}$$

$$47.4 \text{ g} = 0.0474 \text{ kg}$$

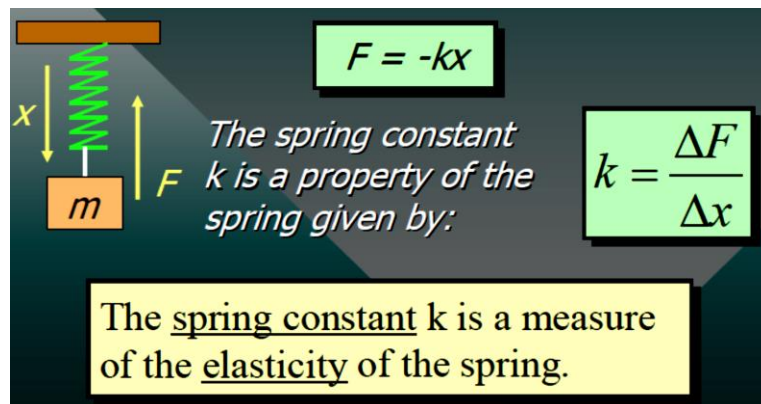
- ❖ Density of a material is a function of temperature
  - ✓ In general, density decreases with increasing temperature.
  - ✓ Volume per unit weight increases with increasing temperature.
  - ✓ **Thermal expansion** is the name for this effect of temperature on density.
  - ✓ **Types of Thermal expansion:**
    1. Linear thermal expansion (thermal expansion in one dimension)
    2. Area thermal expansion (thermal expansion in two dimension)
    3. Volume thermal expansion (thermal expansion in three dimension)

## **Elasticity** المرونة

- ❖ Elasticity: *ability of a deformed material body to return to its original shape and size when the forces causing the deformation are removed.*
- ❖ Modulus of elasticity *the ratio of the stress in a body to the corresponding strain*
- ❖ There are three types of modulus of elasticity, *Young's modulus*, *Shear modulus*, and *Bulk modulus*.
- ❖ A spring is an example of an elastic body that can be deformed by stretching.

## **Hooke's Law**

When a spring is stretched, there is a restoring force that is proportional to the displacement.



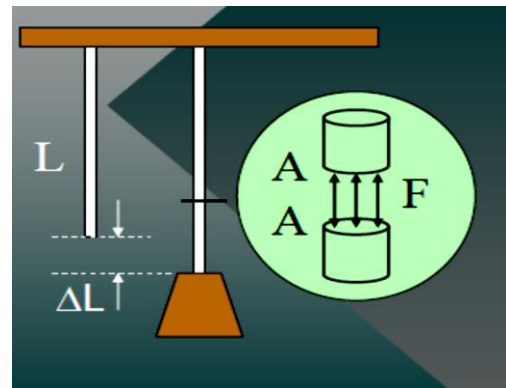
## Stress and Strain

- ❖ Stress is the ratio of an applied force  $F$  to the area  $A$

$$\text{Stress} = \frac{F}{A} \quad \text{Units: Pa} = \frac{\text{N}}{\text{m}^2} \text{ or } \frac{\text{lb}}{\text{in.}^2}$$

- ❖ Strain is the relative change in the dimensions or shape of a body as the result of an applied stress.

$$\text{Strain} = \frac{\Delta L}{L}$$



**Example 1.** A steel wire 10 m long and 2 mm in diameter is attached to the ceiling and a (200 N) weight is attached to the end. What is the applied stress?

First find area of wire:

$$A = \frac{\pi D^2}{4} = \frac{\pi (0.002 \text{ m})^2}{4}$$

$$A = 3.14 \times 10^{-6} \text{ m}^2$$

$$\text{Stress} = \frac{F}{A} = \frac{200 \text{ N}}{3.14 \times 10^{-6} \text{ m}^2} = 6.37 \times 10^7 \text{ Pa}$$

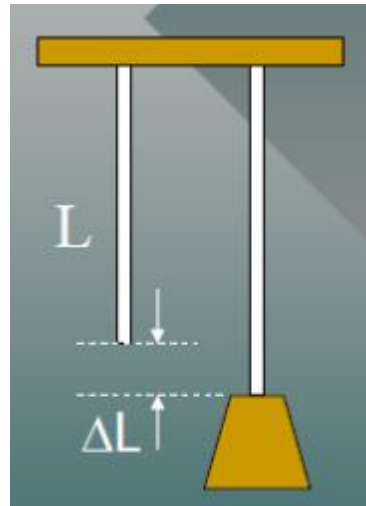
**Example 2:** 10 m steel wire stretches 3.08 mm due to the 200 N load.

What is the longitudinal strain?

$$L = 10 \text{ m}, \Delta L = 3.08 \text{ mm}$$

$$\text{Strain} = \Delta L / L = 0.00308 \text{ m} / 10 \text{ m}$$

$$= 308 \times 10^{-4}$$



- ❖ An elastic deformation (strain) is directly proportional to the magnitude of the applied force per unit area (stress).

$$\text{Modulus of Elasticity} = \frac{\text{stress}}{\text{strain}}$$

**Example 3.** The stress applied to the steel wire was  $6.37 \times 10^7$  Pa and the strain was  $3.08 \times 10^{-4}$  find the modulus of elasticity for steel.

$$\text{Modulus of Elasticity} = \frac{\text{stress}}{\text{strain}} = \frac{6.37 \times 10^7 \text{ Pa}}{3.08 \times 10^{-4}} = 207 \times 10^9 \text{ Pa}$$