MECHANICAL PROPERTIES OF SOLIDS

Important Points:

1. **Elasticity:**

   The property of a body by virtue of which it regains its original size and shape when deformation force is removed is called elasticity.

   Ex: Steel, Rubber.

2. No body is perfectly elastic. Quartz is the nearest example of elastic body.

3. **Plasticity:**

   The property of a body by virtue of which it does not regain the size and shape when the deformation force is removed is called Plasticity.

   Ex: Putty dough, Chewing gum, etc.

4. **Stress:**

   The restoring force per unit area is called Stress.

   $$\text{Stress} = \frac{F}{A}$$

   Unit: N/m^2 or Pascal.

   Dimensional Formula $M^1L^{-1}T^{-2}$

5. **Strain:**

   The change produced per unit dimension is called Strain.

   $$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

6. **Hooke's Law:**

With in the elastic limit, stress is directly proportional to strain.

$$E = \frac{\text{Stress}}{\text{Strain}}$$

E = Modulus of Elasticity

S.I. Unit: N/m^2 or Pascal

7. With in the elastic limit, stress-strain graph is a straight line passing through the origin.

8. Linear strain = $\frac{\text{change in length}(\Delta l)}{\text{original length}(l)}$

Young's Modulus = $\frac{linear\ stress}{linear\ strain} = \frac{Fl}{A\Delta l}$

$$Y = \frac{Fl}{A\Delta l} = \frac{Fl}{Ae} = \frac{mgl}{\pi r^2 e}$$

$$Longitudinal\ \ strain = \frac{change\ \text{in length}}{\text{original length}} = \frac{e}{\ell}$$

9. Bulk strain = $\frac{change\ in\ volume}{original\ volume} = \frac{\Delta v}{v}$

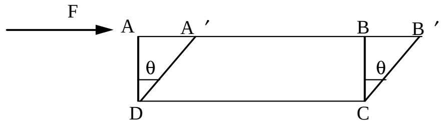
Bulk modulus = $\frac{bulk\ stress}{bulk\ strain} = \frac{-Fv}{A\Delta v}$

$$K = -\frac{PV}{\Delta V}$$

The negative sign indicates that as pressure increases volume decreases.

10. The reciprocal of bulk modulus $\left(\frac{1}{K}\right)$ is called compressibility(C).

11. Shearing strain = $\frac{AA'}{AD}$



$$\text{Tan}\,\theta = \frac{\text{displacement in the upper surface}}{\text{distance between the layers}}$$

$$\text{Rigidity modulus} = \frac{\text{tangential stress}}{\text{tangential strain}}$$

$$\text{n} = \frac{F}{A \times \tan\theta} = \frac{F}{A} \times \left(\frac{AD}{AA'}\right)$$

12. **Poisson's Ratio (σ):**

The ratio of lateral contraction strain to the longitudinal elongation strain is called Poisson's ratio.

$$\sigma = \frac{lateral\ contraction\ \ strain}{longitudinal\ elongation\ \ strain}$$

$$\sigma = \frac{-\left(\Delta r/r\right)}{\left(\Delta l/l\right)}$$

i) It has no units and no dimension.

ii) Theoretical limits of $\sigma = -1\ to\ 0.5$

Practical limits of $\sigma = 0\ to\ 0.5$

13. The work done in stretching a wire

$W = \frac{1}{2}$ Stress x Strain x Volume

Very Short Answer Questions

1. State the Hooke's law of Elasticity.

A. Hooke's Law:

Within the elastic limit, the stress on body is directly proportional to the strain produced in it.

$$\text{Stress} \, \alpha \, \text{strain}$$

Or $E = \dfrac{stress}{strain}$ where E is called modulus of elasticity.

2. State the Units and dimensions of Stress.

A. i) **Units of stress:** Nm^{-2} or Pascal

ii) **Dimensions of stress:** $\left[ML^{-1}T^{-2}\right]$

3. State the units and dimensions of modulus of elasticity.

A. i) **Units of modulus of elasticity:** Nm^{-2} or Pascal

ii) **Dimensions of modulus of elasticity:** $\left[ML^{-1}T^{-2}\right]$

4. State the units and dimensions of Young's modulus.

A. i) **Units of Young's modulus:** Nm^{-2} or Pascal

ii) **Dimensions of Young's modulus:** $\left[ML^{-1}T^{-2}\right]$

5. State the units and dimensions of modulus of rigidity.

A. i) **Units of modulus of rigidity:** Nm^{-2} or Pascal

ii) **Dimensions of modulus of rigidity:** $\left[ML^{-1}T^{-2}\right]$

6. State the units and dimensions of Bulk modulus.

A. i) **Units of Bulk modulus:** Nm^{-2} or Pascal

ii) **Dimensions of Bulk modulus:** $\left[ML^{-1}T^{-2}\right]$

7. State the examples of nearly perfectly elastic and plastic bodies.

A. i) **Nearly perfectly elastic body:** Quartz fiber.

ii) **Nearly perfectly elastic body:** Clay, wax.

Short Answer Questions

1. Define Hooke's law of Elasticity, proportionality limit, permanent set and breaking stress?

A. Hooke's law of Elasticity:

With in the elastic limit, stress is directly proportional to strain.

$$E = \frac{\text{Stress}}{\text{Strain}}$$

E = Modulus of Elasticity

Proportionality Limit:

The maximum stress applied on the wire up to which stress is directly proportional to strain and Hooke's law is obeyed, is called proportionality limit.

Permanent Set:

If the wire is loaded beyond the elastic limit the wire gets stretched to an extent, it deforms permanently It is called permanent set

Breaking Stress:

The stress for which the wire breaks is called breaking stress.

2. Define modulus of elasticity, stress, strain and Poisson's Ratio?

A. Modulus of elasticity:

With in the elastic limit, the ratio of stress and strain is called modulus of elasticity.

$$E = \frac{\text{Stress}}{\text{Strain}}$$

E = Modulus of Elasticity

Stress:

The restoring force per unit area is called stress.

$$\text{Stress} = \frac{\text{Restoring force}}{\text{Area}} = \frac{F}{A}$$

. **Strain:**

The change produced per unit dimension is called strain.

$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

Poisson's Ratio (σ):

The ratio of lateral contraction strain to the longitudinal elongation strain is called Poisson's ratio.

$$\sigma = \frac{\text{lateral contraction strain}}{\text{longitudinal elongation strain}}$$

$$\sigma = \frac{-\left(\Delta r / r\right)}{\left(\Delta l / l\right)}$$

3. Define Young's modulus, Bulk modulus and shear modulus?

A Young's Modulus:

Within the elastic limit, the ratio between longitudinal stresses to longitudinal strain is called Young's modulus.

Young's modulus (Y) = $\frac{longitudinal\,stress}{longitudinal\;\;strain} = \frac{F/A}{e/l}$

Bulk Modulus:

Within the elastic limit, the ratio between volume stress and volume strain is called bulk modulus.

Bulk modulus (K) = $\frac{volume\,stress}{volume\,strain} = \frac{-P}{(\Delta V/V)}$

Shear Modulus:

Within the elastic limit, the ratio between tangential stresses to tangential strain is called rigidity modulus.

Rigidity modulus, **(η) =** $\frac{Tangential\,stress}{Tangential\,strain} = \frac{F/A}{\theta}$

4. Define stress and explain the types of stress?

A. Stress:

The restoring force per unit area is called stress.

Stress = $\frac{\mathrm{F}}{\mathrm{A}}$

Types of Stress:

a) Longitudinal Stress:

If the deforming force causes a change in length of a body, then the restoring force per unit area is called longitudinal or linear or tensile stress.

Longitudinal Stress = $\frac{Restoring\ force}{Area} = \frac{F}{A}$

b) Shearing Stress:

If the deforming force causes a change in the shape of a body at constant volume, then the restoring force per unit area is called shearing stress.

Shearing Stress = $\frac{Restoring\ force}{Area} = \frac{F}{A}$

c) Bulk Stress:

If the deforming force causes a change in volume of a body, then the restoring force per unit area is called bulk or volume stress.

Stress = $\frac{Restoring\ force}{Area} = \frac{F}{A}$

5. Define strain and explain the types of strain?

A. Strain:

The change produced per unit dimension is called strain.

$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

Types of Strain:

a) Longitudinal Strain:

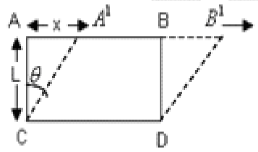
When the deformation force is applied on a body along its length, then the ratio of change in length of the body to its original length is called longitudinal (or) linear strain

Longitudinal strain = $\frac{Change\ in\ length}{Original\ length} = \frac{\Delta L}{L}$

b) Shearing Strain:

When deformation force is applied on a body along a tangential plane to cause the change in the shape of the body, the strain obtained is called shearing strain. It is defined as the ratio of the relative displacement between the two layer's to the normal distance between the two layers

In the figure 'θ' is the measure of shearing strain



From the figure,

$$Tan\,\theta = \frac{x}{L} \Rightarrow \theta = \frac{x}{L}$$

[$\therefore$ If θ is small, then $\tan\theta = \theta$]

c) Bulk Strain:

When deformation force applied on a body causes the change in its volume, then the ratio of change in the volume of the body to its original volume is called volume strain (or) bulk strain

Bulk strain = $\dfrac{Change\,in\,volume}{Original\,volume} = \dfrac{-\Delta V}{V}$

[Here negative sign indicates decrease in volume]

6. Define strain energy and derive the equation for the same.

A. Strain Energy:

The work done in deforming a body is stored as potential energy called strain energy.

Strain energy = $\frac{1}{2} \times stress \times strain \times volume$

Derivation:

Let a deformation force 'F' is applied on a wire of length 'L' and area of cross section 'A'. Let 'x' is the elongation produced. Then $F = \frac{YAx}{L}$

The work done for the elongation dx is given by

$$dW = F.dx \Rightarrow dW = \frac{YAx}{L}dx$$

The total work done for the elongation 'x' is given by

$$\int_0^x dW = \int_0^x dW = \int_0^x \frac{YAx}{L}dx \Rightarrow W = \frac{YAx^2}{2L}$$

This work done will be stored in the form of strain energy

$$\therefore E = \frac{YAx^2}{2l}$$

Strain energy $E = \frac{1}{2} \times \frac{Y x}{L} \times \frac{x}{L} \times AL$

Or $E = \frac{1}{2} \times stress \times strain \times volume$

7. **Explain why steel is preferred to copper, brass, aluminium in heavy-duty machines and in structural designs?**

A. The Young's modulus of steel is $2\times10^{11}\ Nm^{-2}$. But for copper, brass and aluminum, these values are less than for steel. That is steel is more than that of copper, brass and **Aluminium** .Hence steel is preferred to copper, brass, **Aluminium** in heavy-duty machines and in structural designs.

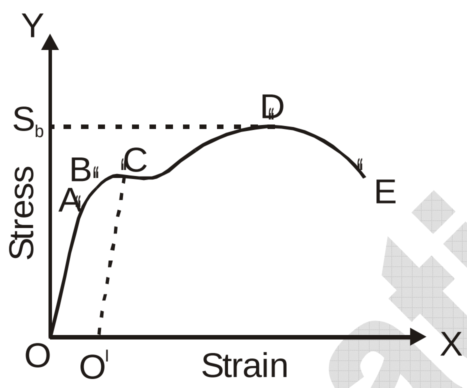
8. Describe the behavior of a wire under gradually increasing load.

A Behavior of a wire under increasing load:

A graph drawn by taking strain on x-axis and stress on y-axis is shown.

Proportionality Limit:

The maximum stress applied on the wire up to which Hooke's law is obeyed is called proportional limit .The point 'A' is called the proportional limit.



Elastic Limit:

Between A and B, the wire does not obey Hooke's law.

The point 'B' is called Elastic limit.

Permanent Set:

If the wire is loaded beyond 'B', the wire deforms permanently. It is called permanent set.

Yielding Point:

Beyond 'C', the extension in the wire increases rapidly without an increase in the load. This is called yielding point.

Breaking Point:

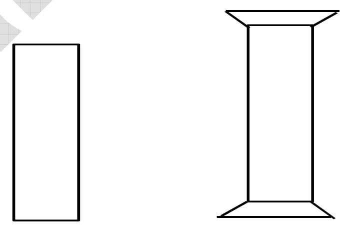
Beyond D the wire becomes thin and it finally breaks at ‘E’. At point ‘D’, the stress is the ultimate tensile strength of given material.

9. Two identical balls, one ivory and the other of wet- clay are dropped from the same height onto the floor. Which one will rise to a greater height after striking the floor and why?

A. Let two identical balls, one ivory and the other of wet- clay are dropped from the same height onto the floor. Ivory is more elastic than wet-clay. The ball which more elastic will rise to a greater height. Hence Ivory ball will rise to a greater height.

10. While constructing buildings and bridges a pillar with distributed ends is Preferred to a pillar with rounded ends why?

A. Use of pillars or columns is also very common in buildings and bridges. A pillar With rounded ends as shown in figure (a) supports less load than that with a disturbed Shape at the ends as shown in figure (b). The precise design of a bridge or a building has To take into account the conditions under which it will function, the cost and long Period, reliability of usable materials



(a) (b)

11. Explain why the maximum height of a mountain on earth is approximately 10km?

A: The maximum height of mountain on earth depends upon shear modulus of rock. At the base of the mountain, the stress due to all the rock on the top should be less than the critical shear stress at which the rock begins to flow. Suppose the height of the mountain is h and the density of its rock is ρ. Then force per unit area (due to the weight of the mountain) at the base $= h\rho g$

The material at the experience this force per unit area in the vertical direction, but sides of the mountain area free. Hence there is a tangential shear of the order of $h\rho g$. The elastic limit for a typical rock is about $3\times10^{8}\,Nm^{-2}$ and its density is $3\times10^{3}\,kgm^{-3}$

Hence $h_{\max}\rho g = 3\times10^{8}$

Or $h_{\max} = \dfrac{3\times10^{8}}{\rho g} = \dfrac{3\times10^{8}}{3\times10^{3}\times9.8} = 10,000m = 10km$

This is more than the height of the Mount Everest.

12. Explain the concept of elastic potential energy in a stretched wire and hence obtain the expression for it?

A. When a wire is stretched, the work done against the inter-atomic forces is stored as elastic potential energy.

Derivation:

Let a deformation force 'F' is applied on a wire of length 'L' and area of cross section 'A'. Let 'x' is the elongation produced. Then $F = \dfrac{YAx}{L}$

The work done for the elongation dx is given by

$$dW = F.d\,x \Rightarrow \quad dW = \frac{YAx}{L}dx$$

The total work done for the elongation 'x' is given by

$$\int_0^x dW = \int_0^x dW = \int_0^x \frac{YAx}{L} dx \Rightarrow W = \frac{YAx^2}{2L}$$

This work done will be stored in the form of strain energy

$$\therefore E = \frac{YAx^2}{2l}$$

Strain energy $E = \frac{1}{2} \times \frac{Y x}{L} \times \frac{x}{L} \times AL$

Or $E = \frac{1}{2} \times stress \times strain \times volume$

Long Answer Questions

1. Define Hooke's Law of Elasticity.

Describe the experiment to determine the Young's modulus of the material of the wire.

A. Hooke's Law:

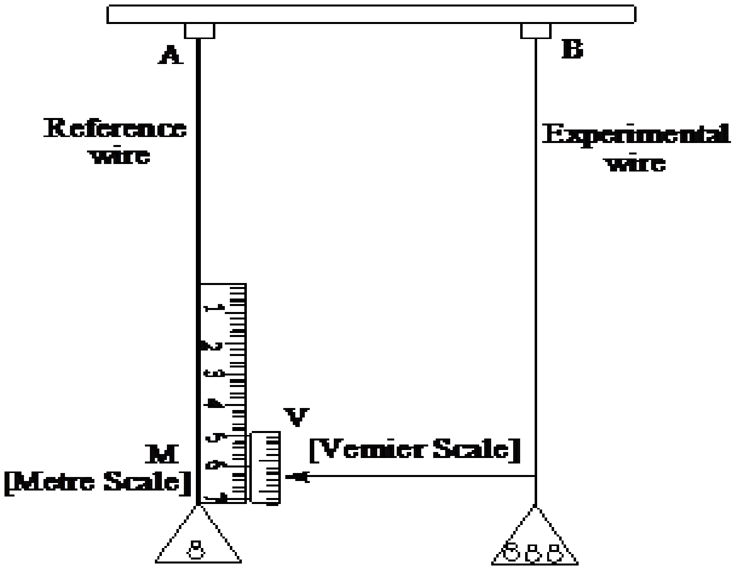
Within the elastic limit the stress on body is directly proportional to the strain produced in it.

I.e. stress α strain

E = $\frac{stress}{strain}$ where E is called modulus of elasticity.

Determination of Young's Modulus:

Description:



Two metallic wires A and B of same length, same material and same radii are suspended from a rigid support. The wire A is called reference Wire and the wire B is called experimental Wire. The wire A carries a millimeter scale M and a pan to place the weights. The wire B carries a pan in which unknown Weights are placed. A vernier V is attached to a pointer at the bottom of the wire B and to the main scale.

Procedure:

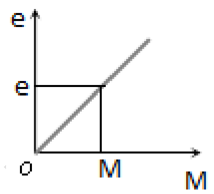
The initial length '*l*' and radius 'r' of wire B is measured. Both the wire are made straight by putting same load on the pans. The Vernier reading is noted. Now the experimental wire is loaded (M) and the Vernier reading is again noted. The difference of these two readings gives the extension (e) of the wire. Vernier reading repeats the same by adding loads to the weight hanger in regular steps and also by unloading .The difference between the average of loading and unloading values and initial reading gives the extension (e) of the wire. The Values are tabulated as below.

S. no	Mass,M	Vernier reading		Average	elongation e	$\frac{M}{e}$
		While decreasing the weights	While increasing the weights			

Average value of $= \frac{M}{e}$

Graph:

A graph is plotted between elongation (M) on x-axis and varying values of 'e' on y-axis. $\frac{M}{e}$ is calculated from the graph.



The value of Young's modulus can be determined by using the formula, Young's modulus of wire,

$$Y = \frac{gl}{\pi r^2}\left(\frac{M}{e}\right)$$

Problems

1. A copper wire of 1 mm diameter is stretched by applying a force of 10 N. Find the stress in the wire

A. Stress = $\dfrac{\text{Force}}{\text{Area}} = \dfrac{F}{\pi r^2} = \dfrac{10}{\frac{22}{7}\times 5\times 10^{-4}\times 5\times 10^{-4}}$ = 1.273 10^7 Nm^{-2}

2. A tungsten wire of length 20 cm is stretched by 0.1 cm. Find the strain on the wire.

A. L = 20 cm; $\Delta L = 0.1 cm$

Strain = $\dfrac{\Delta L}{L} = \dfrac{0.1}{20}$ = 5 x 10^{-3}

3. If an iron wire is stretched by 1% what is the strain on the wire?

A: $\dfrac{\Delta L}{L} = \dfrac{1}{100}$

$\therefore$ Strain = 10^{-2}

4. A brass wire of diameter 1mm and length 2m is stretched by applying a force of 20N. If the increase in length is 0.51mm find i) the stress ii) the strain and iii) the young's modulus of the wire?

A: d = 2r = 1mm $\Rightarrow r = 0.5 mm = 5\times 10^{-4} m$; L = 2m

F = 20N; $\Delta L = 0.51 mm = 51\times 10^{-5} m$

i) Stress $= \dfrac{F}{A} = \dfrac{F}{\pi r^2} = \dfrac{20}{\frac{22}{7}\times (5\times 10^{-4})^2} = 2.546\times 10^7 Nm^{-2}$

ii) Strain $= \dfrac{\Delta L}{L} = \dfrac{51\times 10^{-5}}{2} = 0.255\times 10^{-3} m$

iii) Young's modulus, $Y = \dfrac{stress}{strain} = \dfrac{2.546\times 10^7}{0.255\times 10^{-3}} = 9.984\times 10^{10} Nm^{-2}$

5. A copper wire and an Aluminium wire have lengths in the ratio 3: 2, diameters in the ratio 2: 3 and forces applied in the ratio 4: 5. Find the ratio of the increase in length of the two wires? (Y_{Cu} = 1.1 x 10^{11} N m^{-2} , Y_{Al} = 0.70 × 10^{11} N m^{-2} `)

A. $L_1 : L_2 = 3 : 2$; $D_1 : D_2 = 2 : 3$; $Y_1 = 1.1 10^{11}$ Nm^{-2} ; $Y_2 = 0.70 \times 10^{11}$ Nm^{-2}

$F_1 : F_2 = 4 : 5$ $r_1 : r_2 = 2 : 3$

$\Delta L_1 : \Delta L_2 = ?$

$$Y = \frac{F}{\pi r^2}\frac{L}{\Delta L} \Rightarrow \Delta L = \frac{FL}{Y\pi r^2}$$

$$\frac{\Delta L_1}{\Delta L_2} = \frac{F_1}{F_2}\frac{L_1}{L_2}\frac{r_2^2}{r_1^2}\frac{Y_2}{Y_1} = \frac{4}{5}\times\frac{3}{2}\times\frac{9}{4}\times\frac{0.7}{1.1} = \frac{189}{110}$$

6. A brass wire of cross sectional area $2mm^2$ is suspended from a rigid support and a body of volume $100cm^3$ is attached to its other end. If the decreases in the length of the wire is 0.11mm, when the body is completely immersed in water, find the natural length of the wire $(Y_{brass} = 0.91\times10^{11} Nm^{-2}, \rho_{water} = 10^3 kgm^{-3})$

A: $A = 2mm^2 = 2\times10^{-6} m^2$; $V = 100cm^3 = 10^{-4} m^3$

$\Delta L = 0.11mm = 11\times10^{-5} m$ **;** $Y_b = 0.91\times10^{11} Nm^{-2}$**,** $\rho_w = 10^3 Kgm^{-3}$

Using $Y_b = \frac{FL}{A\Delta L} = \frac{MgL}{A\Delta L} = \frac{V\rho_w gL}{A\Delta L}$

$$L = \frac{Y_b A\Delta L}{V\rho_2 g} = \frac{0.91\times10^{11}\times2\times10^{-6}\times11\times10^{-5}}{10^{-4}\times10^3\times9.8} = 2.043m$$

7. There are two wires of same material. Their radii and lengths are both in the ratio 1: 2. If the extensions produced are equal, what is the ratio of the loads?

A. $r_1 : r_2 = 1 : 2$; $l_1 : l_2 = 1 : 2$; $e_1 = e_2$; $Y_1 = Y_2$

$$Y = \frac{Mg}{\pi r^2}\frac{L}{e}$$

$$\Rightarrow \frac{M_1}{M_2} = \frac{L_2}{L_1} \times \frac{r_1^2}{r_2^2} = \frac{2}{1} \times \frac{1}{4} = \frac{1}{2}$$

8. Two wires of different material have same lengths and areas of cross-section. What is the ratio of their increase in length when forces applied are the same?

$(Y_1 = 0.9 \times 10^{11}\, Nm^{-2}, Y_2 = 3.6 \times 10^{11}\, Nm^{-2})$

A: $L_1 = L_2 = L$ **;** $A_1 = A_2 = A$ **;** $F_1 = F_2 = F$ **;** $Y_1 = 0.90 \times 10^{11}\, Nm^{-2}$

$Y_2 = 3.6 \times 10^{11}\, Nm^{-2}$ **;** $\frac{\Delta L_1}{\Delta L_2} = ?$

$$\frac{\Delta L_1}{\Delta L_2} = \frac{F_1 L_1}{A_1 Y_1} \times \frac{A_2 Y_2}{F_2 L_2} = \frac{Y_2}{Y_1} \qquad \left[\because Y = \frac{FL}{A\Delta L}\right]$$

$$\frac{\Delta L_1}{\Delta L_2} = \frac{3.6 \times 10^{11}}{0.9 \times 10^{11}} = \frac{4}{1} \qquad \therefore \frac{\Delta L_1}{\Delta L_2} = 4:1$$

9. A metal wire of length 2.5 m and area of cross section 1.5 x 10^{-6} m^2 is stretched through 2 mm. If its Young's modulus is 1.25 $\times$ 10^{11} Nm^{-2}, find the tension in the wire.

A. L = 2.5 m ; A = 1.5 x 10^{-6} m^2 ; e = 2 mm = 2$\times$ 10^{-3} m ; Y = 1.25 $\times$ 10^{11} Nm^{-2} F = ?

$$F = \frac{YAe}{L} = \frac{1.25 \times 10^{11} \times 1.5 \times 10^{-6} \times 2 \times 10^{-3}}{2.5} = 150 \text{ N}$$

10. An Aluminium wire and a steel wire of the same length and cross section are joined end-to-end. The composite wire is hung from a rigid support and a load is suspended ratio of the i) stress in the two wires and ii) strain in the two wires

$(Y_{Al} = 0.7\times10^{11}\,Nm^{-2}; Y_{steel} = 2\times10^{11}\,Nm^{-2})$

A: $L_1 = L_2 = L$; $A_1 = A_2 = A$; $F_1 = F_2 = F$;

$Y_1 = 7\times10^{10}\,Nm^{-2}$; $Y_2 = 2\times10^{11}\,Nm^{-2}$;

$\Delta L = \Delta L_1 + \Delta L_2 = 1.35mm$

i) $\dfrac{stress, S_1}{stress, S_2} = \dfrac{F_1}{A_1}\times\dfrac{A_2}{F_2} = \dfrac{FA}{AF} = 1$ $\qquad \therefore S_1 : S_2 = 1:1$

ii) $\dfrac{\Delta L_1}{\Delta L_2} = \dfrac{Y_2}{Y_1} = \dfrac{2\times10^{11}}{7\times10^{10}} = \dfrac{20}{7}$ $\qquad \left[\because \Delta L = \dfrac{FL}{AY}\right]$

$\therefore \Delta L_1\ \Delta L_2 = 20:7$

11. A 2 cm cube of some substance has its upper face displaced by 0.15 cm, by a tangential force of 0.30 N fixing its lower face. Calculate the rigidity modulus of the substance?

A. $\tan\theta = \dfrac{\text{Displacement in the upper surface}}{\text{distance between the layers}} = \dfrac{0.15}{2}$

$$\eta = \frac{F}{A\times\text{Tan}\,\theta}$$

$$\eta = \frac{F}{A\times\text{Tan}\,\theta} = \frac{0.3\times2}{4\times10^{-4}\times0.15} = 10^4\ \text{Pa}$$

12. A spherical ball of volume $1000cm^3$ is subjected to a pressure of 10 atmosphere. The change in volume is $10^{-2}cm^3$. If the ball is made of iron, find its bulk modulus. (1 atmosphere $=1\times10^5 Nm^{-2}$)

A: $V=1000cm^3=10^{-3}m^3$; $P=10atm=10\times10^5 Nm^{-2}$

$=10^6 Nm^{-2}$; $\Delta V=10^{-2}cm^3=10^{-8}m^3$

$$K=\frac{PV}{\Delta V}=\frac{10\times10^5\times10^{-3}}{10^{-8}}=1\times10^{11} Nm^{-2}$$

3. A copper cube of side of length 1cm is subjected to a pressure of 100 atmosphere. Find the change in its volume if the bulk modulus of copper is $1.4\times10^{11}m^{-2}$.

$(1atm=1\times10^5 Nm^{-2})$

A: $L=1cm=1\times10^{-2}m$; $\Rightarrow V=L^3=10^{-6}m^3$; P = 100atm

$=100\times10^5 Nm^{-2}$; $K=1.4\times10^{11} Nm^{-2}$

$$\Delta V=\frac{PV}{K}=\frac{100\times10^5\times10^{-6}}{1.4\times10^{11}}=0.7143\times10^{-10}m^3$$

14. Determine the pressure required to reduce the given volume of water by 2%. Bulk modulus of water is 2.2 x 10^9 N m^{-2}?

A. $K=2.2\times10^9 Nm^{-2}$; $\frac{\Delta V}{V}=2\%=\frac{2}{100}$

$$P = K\frac{\Delta V}{V} = 2.2 \times 10^9 = 4.4 \times 10^7 Nm^{-2}$$

15. A steel wire of length 20cm is stretched to increase its length by 0.2cm. Find the lateral strain in the wire if the poisson's ratio for steel is 0.19?

A: $L=20cm=2\times10^{-1}m$; $\Delta L=0.2cm=2\times10^{-3}m$;

$\sigma=0.19$

Lateral strain $=\sigma\times$longitudinal strain $=0.19\times\frac{1}{100}=0.0019$.