Chapter 7

Mechanical Properties of Solids

1. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area A and wire 2 has cross-sectional area $3A$. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount ? **[AIEEE-2009]**

   (1) $4F$ (2) $6F$

   (3) $9F$ (4) F

2. A metal rod of Young's modulus Y and coefficient of thermal expansion α is held at its two ends such that its length remains invariant. If its temperature is raised by t°C, the linear stress developed in it is **[AIEEE-2011]**

   (1) $\frac{1}{(Y\alpha t)}$ (2) $\frac{\alpha t}{Y}$

   (3) $\frac{Y}{\alpha t}$ (4) $Y\alpha t$

3. A man grows into a giant such that his linear dimensions increase by a factor of 9. Assuming that his density remains same, the stress in the leg will change by a factor of **[JEE (Main)-2017]**

   (1) 9 (2) $\frac{1}{9}$

   (3) 81 (4) $\frac{1}{81}$

4. A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area of a floats on the surface of the liquid, covering entire cross-section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\frac{dr}{r}\right)$, is **[JEE (Main)-2018]**

   (1) $\frac{Ka}{mg}$ (2) $\frac{Ka}{3mg}$

   (3) $\frac{mg}{3Ka}$ (4) $\frac{mg}{Ka}$

5. A rod, length L at room temperature and uniform area of cross section A, is made of a metal having coefficient of linear expansion α/°C. It is observed that an external compressive force F, is applied on each of its ends, prevents any change in the length of the rod, when its temperature rises by ΔTk. Young's modulus, Y, for this metal is **[JEE (Main)-2019]**

   (1) $\frac{F}{A\alpha(\Delta T-273)}$ (2) $\frac{F}{A\alpha\Delta T}$

   (3) $\frac{2F}{A\alpha\Delta T}$ (4) $\frac{F}{2A\alpha\Delta T}$

6. A load of mass M kg is suspended from a steel wire of length 2 m and radius 1.0 mm in Searle's apparatus experiment. The increase in length produced in the wire is 4.0 mm. Now th load is fully immersed in a liquid of relative density 2. The relative density of the material of load is 8.

   The new value of increase in length of the steel wire is **[JEE (Main)-2019]**

   (1) 4.0 mm (2) Zero

   (3) 5.0 mm (4) 3.0 mm

7. A steel wire having a radius of 2.0 mm, carrying a load of 4 kg, is hanging from a ceiling. Given that $g = 3.1\,\pi$ ms^{-2}, what will be the tensile stress that would be developed in the wire? **[JEE (Main)-2019]**

   (1) 4.8×10^6 Nm^{-2} (2) 3.1×10^6 Nm^{-2}

   (3) 5.2×10^6 Nm^{-2} (4) 6.2×10^6 Nm^{-2}

8. A boy's catapult is made of rubber cord which is 42 cm long, with 6 mm diameter of cross-section and of negligible mass. The boy keeps a stone weighing 0.02 kg on it and stretches the cord by 20 cm by applying a constant force. When released, the stone flies off with a velocity of 20 ms^{-1}. Neglect the change in the area of cross-section of the cord while stretched. The Young's modulus of rubber is closest to **[JEE (Main)-2019]**

   (1) 10^4 Nm^{-2} (2) 10^3 Nm^{-2}

   (3) 10^8 Nm^{-2} (4) 10^6 Nm^{-2}

9. Young's moduli of two wires *A* and *B* are in the ratio 7 : 4. Wire *A* is 2 m long and has radius *R*. Wire *B* is 1.5 m long and has radius 2 mm. If the two wires stretch by the same length for a given load, then the value of *R* is close to **[JEE (Main)-2019]**

(1) 1.3 mm (2) 1.9 mm

(3) 1.5 mm (4) 1.7 mm

10. In an experiment, brass and steel wires of length 1 m each with areas of cross section 1 mm^2 are used. The wires are connected in series and one end of the combined wire is connected to a rigid support and other end is subjected to elongation. The stress required to produce a net elongation of 0.2 mm is,

[Given, the Young's Modulus for steel and brass are, respectively, 120×10^9 N/m^2 and 60×10^9 N/m^2] **[JEE (Main)-2019]**

(1) 1.8×10^6 N/m^2 (2) 1.2×10^6 N/m^2

(3) 8.0×10^6 N/m^2 (4) 0.2×10^6 N/m^2

11. The elastic limit of brass is 379 MPa. What should be the minimum diameter of a brass rod if it is to support a 400 N load without exceeding its elastic limit? **[JEE (Main)-2019]**

(1) 0.90 mm (2) 1.16 mm

(3) 1.00 mm (4) 1.36 mm

12. Two steel wires having same length are suspended from a ceiling under the same load. If the ratio of their energy stored per unit volume is 1 : 4, the ratio of their diameters is **[JEE (Main)-2020]**

(1) $\sqrt{2}:1$

(2) 2 : 1

(3) $1:\sqrt{2}$

(4) 1 : 2

13. A cube of metal is subjected to a hydrostatic pressure of 4 GPa. The percentage change in the length of the side of the cube is close to

(Given bulk modulus of metal, $B = 8 \times 10^{10}$ Pa)

[JEE (Main)-2020]

(1) 0.6

(2) 20

(3) 1.67

(4) 5

14. A body of mass m = 10 kg is attached to one end of a wire of length 0.3 m. The maximum angular speed (in rad s^{-1}) with which it can be rotated about its other end in space station in (Breaking stress of wire = 4.8×10^7 Nm^{-2} and area of cross-section of the wire = 10^{-2} cm^2) is

[JEE (Main)-2020]

15. If Y, K and η are the values of Young's modulus, bulk modulus and modulus of rigidity of any material respectively. Choose the correct relation for these parameters. **[JEE (Main)-2021]**

(1) $Y = \dfrac{9K\eta}{3K-\eta} N/m^2$

(2) $Y = \dfrac{9K\eta}{2\eta+3K} N/m^2$

(3) $K = \dfrac{Y\eta}{9\eta-3Y} N/m^2$

(4) $\eta = \dfrac{3YK}{9K+Y} N/m^2$

16. A uniform metallic wire is elongated by 0.04 m when subjected to a linear force F. The elongation, if its length and diameter is doubled and subjected to the same force will be _____cm.

[JEE (Main)-2021]

17. The normal density of a material is ρ and its bulk modulus of elasticity is K. The magnitude of increase in density of material, when a pressure P is applied uniformly on all sides, will be :

[JEE (Main)-2021]

(1) $\dfrac{\rho P}{K}$ (2) $\dfrac{\rho K}{P}$

(3) $\dfrac{K}{\rho P}$ (4) $\dfrac{PK}{\rho}$

18. An object is located at 2 km beneath the surface of the water. If the fractional compression $\dfrac{\Delta V}{V}$ is 1.36%, the ratio of hydraulic stress to the corresponding hydraulic strain will be _______.

[Given: density of water is 1000 kgm^{-3} and g = 9.8 ms^{-2}] **[JEE (Main)-2021]**

(1) 1.44×10^7 Nm^{-2} (2) 2.26×10^9 Nm^{-2}

(3) 1.96×10^7 Nm^{-2} (4) 1.44×10^9 Nm^{-2}

19. Two separate wires A and B are stretched by 2 mm and 4 mm respectively, when they are subjected to a force of 2 N. Assume that both the wires are made up of same material and the radius of wire B is 4 times that of the radius of wire A. The length of the wires A and B are in the ratio of a : b Then $\dfrac{a}{b}$ can be expressed as $\dfrac{1}{x}$ where x is ____. **[JEE (Main)-2021]**

20. The value of tension in a long thin metal wire has been changed from T_1 to T_2. The lengths of the metal wire at two different values of tension T_1 and T_2 are l_1 and l_2 respectively. The actual length of the metal wire is **[JEE (Main)-2021]**

(1) $\sqrt{T_1 T_2 l_1 l_2}$ (2) $\dfrac{T_1 l_1 - T_2 l_2}{T_1 - T_2}$

(3) $\dfrac{T_1 l_2 - T_2 l_1}{T_1 - T_2}$ (4) $\dfrac{l_1 + l_2}{2}$

21. The length of a metal wire is l_1, when the tension in it is T_1 and is l_2 When the tension is T_2. The natural length of the wire is: **[JEE (Main)-2021]**

(1) $\sqrt{l_1 l_2}$ (2) $\dfrac{l_1 T_2 - l_2 T_1}{T_2 - T_1}$

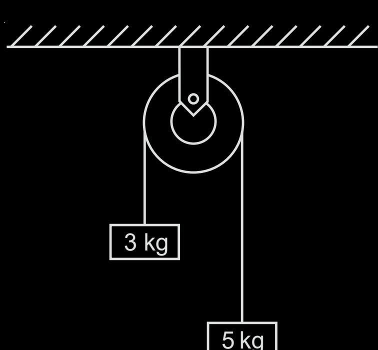
(3) $\dfrac{l_1 + l_2}{2}$ (4) $\dfrac{l_1 T_2 + l_2 T_1}{T_2 + T_1}$

22. Two wires of same length and radius are joined end to end and loaded. The Young's modulii of the materials of the two wires are Y_1 and Y_2. The combination behaves as a single wire then its Young's modulus is **[JEE (Main)-2021]**

(1) $Y = \dfrac{2Y_1Y_2}{3(Y_1 + Y_2)}$ (2) $Y = \dfrac{Y_1Y_2}{2(Y_1 + Y_2)}$

(3) $Y = \dfrac{2Y_1Y_2}{Y_1 + Y_2}$ (4) $Y = \dfrac{Y_1Y_2}{Y_1 + Y_2}$

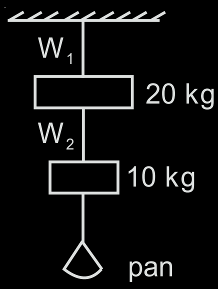
23. Two blocks of masses 3 kg and 5 kg are connected by a metal wire going over a smooth pulley. The breaking stress of the metal is $\dfrac{24}{\pi} \times 10^2\ \text{Nm}^{-2}$. What is the minimum radius of the wire? (take g = 10 ms^{-2}) **[JEE (Main)-2021]**



(1) 1250 cm
(2) 125 cm
(3) 1.25 cm
(4) 12.5 cm

24. Wires W_1 and W_2 are made of same material having the breaking stress of 1.25×10^9 N/m^2. W_1 and W_2 have cross-sectional area of 8×10^{-7} m^2 and 4×10^{-7} m^2, respectively. Masses of 20 kg and 10 kg hang from them as shown in the figure. The maximum mass that can be placed in the pan without breaking the wires is ___ kg.

(Use g = 10 m/s^2) **[JEE (Main)-2021]**



25. A uniform heavy rod of weight 10 kg ms^{-2}, cross-sectional area 100 cm^2 and length 20 cm is hanging from a fixed support. Young's modulus of the material of the rod is 2×10^{11} Nm^{-2}. Neglecting the lateral contraction, find the elongation of rod due to its own weight : **[JEE (Main)-2021]**

(1) 5×10^{-8} m
(2) 5×10^{-10} m
(3) 2×10^{-9} m
(4) 4×10^{-8} m

26. Four identical hollow cylindrical columns of mild steel support a big structure of mass 50×10^3 kg. The inner and outer radii of each column are 50 cm and 100 cm respectively. Assuming uniform local distribution, calculate the compression strain of each column. **[JEE (Main)-2021]**

[use Y = 2.0×10^{11} Pa, g = 9.8 m/s^2]

(1) 3.60×10^{-8}
(2) 1.87×10^{-3}
(3) 7.07×10^{-4}
(4) 2.60×10^{-7}

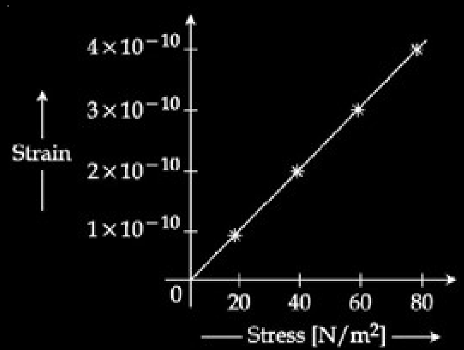
27. A steel rod with $y = 2.0 \times 10^{11}$ Nm^{-2} and $\alpha = 10^{-5}$ °C^{-1} of length 4 m and area of cross-section 10 cm^2 is heated from 0°C to 400°C without being allowed to extend. The tension produced in the rod is $x \times 10^5$ N where the value of x is ______. **[JEE (Main)-2021]**

28. The bulk modulus of a liquid is 3×10^{10} Nm^{-2}. The pressure required to reduce the volume of liquid by 2% is **[JEE (Main)-2022]**

(1) 3×10^8 Nm^{-2} (2) 9×10^8 Nm^{-2}

(3) 6×10^8 Nm^{-2} (4) 12×10^8 Nm^{-2}

29. The elastic behaviour of material for linear stress and linear strain, is shown in the figure. The energy density for a linear strain of 5×10^{-4} is ____ kJ/m^3. Assume that material is elastic upto the linear strain of 5×10^{-4}. **[JEE (Main)-2022]**



30. The elongation of a wire on the surface of the earth is 10^{-4} m. The same wire of same dimensions is elongated by 6×10^{-5} m on another planet. The acceleration due to gravity on the planet will be ___ ms^{-2}. (Take acceleration due to gravity on the surface of earth = 10 ms^{-2}) **[JEE (Main)-2022]**

31. A wire of length L is hanging from a fixed support. The length changes to L_1 and L_2 when masses 1 kg and 2 kg are suspended respectively from its free end. Then the value of L is equal to **[JEE (Main)-2022]**

(1) $\sqrt{L_1 L_2}$

(2) $\frac{L_1 + L_2}{2}$

(3) $2L_1 - L_2$

(4) $3L_1 - 2L_2$

32. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force F, its length increases by 5 cm. Another wire of the same material of length $4L$ and radius $4r$ is pulled by a force $4F$ under same conditions. The increase in length of this wire is ___ cm. **[JEE (Main)-2022]**

33. A square aluminium (shear modulus is 25×10^9 Nm^{-2}) slab of side 60 cm and thickness 15 cm is subjected to a shearing force (on its narrow face) of 18.0×10^4 N. The lower edge is riveted to the floor. The displacement of the upper edge is ______ μm. **[JEE (Main)-2022]**

34. A steel wire of length 3.2 m ($Y_s = 2.0 \times 10^{11}$ Nm^{-2}) and a copper wire of length 4.4 m ($Y_c = 1.1 \times 10^{11}$ Nm^{-2}), both of radius 1.4 mm are connected end to end. When stretched by a load, the net elongation is found to be 1.4 mm. The load applied, in Newton, will be:

(Given $\pi = \frac{22}{7}$) **[JEE (Main)-2022]**

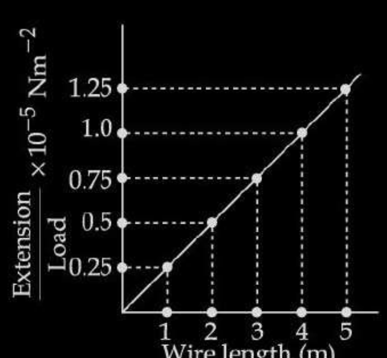
(1) 360

(2) 180

(3) 1080

(4) 154

35. In an experiment to determine the Young's modulus, steel wires of five different lengths (1, 2, 3, 4 and 5 m) but of same cross section (2 mm^2) were taken and curves between extension and load were obtained. The slope (extension/load) of the curves were plotted with the wire length and the following graph is obtained. If the Young's modulus of given steel wires is $x \times 10^{11}$ Nm^{-2}, then the value of x is ______. **[JEE (Main)-2022]**



36. The force required to stretch a wire of cross-section $1\ cm^2$ to double its length will be:

(Given Young's modulus of the wire = $2 \times 10^{11}\ N/m^2$)

[JEE (Main)-2022]

(1) 1×10^7 N (2) 1.5×10^7 N

(3) 2×10^7 N (4) 2.5×10^7 N

37. A string of area of cross-section $4\ mm^2$ and length 0.5 m is connected with a rigid body of mass 2 kg. The body is rotated in a vertical circular path of radius 0.5 m. The body acquires a speed of 5 m/s at the bottom of the circular path. Strain produced in the string when the body is at the bottom of the circle is ______$\times 10^{-5}$.

(use Young's modulus $10^{11}\ N/m^2$ and $g = 10\ m/s^2$)

[JEE (Main)-2022]

38. If the length of a wire is made double and radius is halved of its respective values. Then, the Young's modulus of the material of the wire will :

[JEE (Main)-2022]

(1) Remain same

(2) Become 8 times its initial value

(3) Become $\frac{1}{4}$th of its initial value

(4) Become 4 times its initial value

39. A metal wire of length 0.5 m and cross-sectional area $10^{-4}\ m^2$ has breaking stress $5 \times 10^8\ Nm^{-2}$. A block of 10 kg is attached at one end of the string and is rotating in a horizontal circle. The maximum linear velocity of block will be _____ ms^{-1}.

[JEE (Main)-2022]

40. A uniform heavy rod of mass 20 kg, cross sectional area $0.4\ m^2$ and length 20 m is hanging from a fixed support. Neglecting the lateral contraction, the elongation in the rod due to its own weight is $x \times 10^{-9}$ m. The value of x is _____

(Given Young's modulus $Y = 2 \times 10^{11}\ Nm^{-2}$ and $g = 10\ ms^{-2}$) **[JEE (Main)-2022]**

41. The area of cross section of the rope used to lift a load by a crane is $2.5 \times 10^{-4}\ m^2$. The maximum lifting capacity of the crane is 10 metric tons. To increase the lifting capacity of the crane to 25 metric tons, The required area of cross section of the rope should be

(take $g = 10\ ms^{-2}$) **[JEE (Main)-2022]**

(1) $6.25 \times 10^{-4}\ m^2$

(2) $10 \times 10^{-4}\ m^2$

(3) $1 \times 10^{-4}\ m^2$

(4) $1.67 \times 10^{-4}\ m^2$

❑ ❑ ❑

Chapter 7

Mechanical Properties of Solids

1. Answer (3)

$$\frac{F}{A} = Y\frac{\Delta l}{l}$$

$$\Rightarrow \ F = Y\frac{\Delta l A^2}{Al} = Y\frac{\Delta l A^2}{V}$$

$$\Rightarrow F \propto A^2$$

$$\Rightarrow \frac{F}{F'} = \frac{1}{9}$$

$$\Rightarrow F' = 9F$$

2. Answer (4)

$$\frac{\Delta l}{l} = \alpha t$$

Stress $= Y\alpha t$

3. Answer (1)

$$\frac{v_f}{v_i} = 9^3$$

$\because$ Density remains same

So, mass $\propto$ Volume

$$\frac{m_f}{m_i} = 9^3$$

$$\frac{(\text{Area})_f}{(\text{Area})_i} = 9^2$$

$$\text{Stress} = \frac{(\text{Mass}) \times g}{\text{Area}}$$

$$\frac{\sigma_2}{\sigma_1} = \left(\frac{m_f}{m_i}\right)\left(\frac{A_i}{A_f}\right)$$

$$= \frac{9^3}{9^2} = 9$$

4. Answer (3)

$$K = -V\frac{dP}{dV}$$

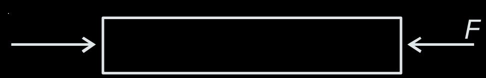
$$\Rightarrow \frac{-dV}{V} = \frac{dP}{K} = \frac{mg}{Ka}$$

$$\Rightarrow \frac{-3dr}{r} = \frac{mg}{Ka}$$

$$\Rightarrow \frac{dr}{r} = -\frac{mg}{3Ka}$$

5. Answer (2)

$\Delta L_{\text{Thermal}} = L_0\, \alpha\, \Delta T$ (+ve)



$$\Delta L_{\text{Mechanical}} = \frac{FL_0}{AY} \ (-ve)$$

$$\Delta L_{\text{eff}} = 0 \quad \therefore \quad L_0\, \alpha\, \Delta T = \frac{FL_0}{AY}$$

$$\Rightarrow \ Y = \frac{F}{A\alpha\Delta T} = \frac{F}{A\alpha\Delta T}$$

6. Answer (4)

Area of wire $A = \pi r^2$

$$\frac{Mg}{\pi r^2} = \frac{\Delta\ell}{\ell_0}Y$$

$$\Rightarrow \frac{Mg}{\pi r^2} = \frac{4 \times 10^{-3}}{2} \cdot Y \quad \text{...(i)}$$

$8v_0\rho_0 = M$

Now when load is immersed in liquid then

$$\frac{8v_0\rho_0 g - 2v_0\rho_0 g}{\pi r^2} = \frac{\Delta\ell'}{\ell_0}Y \quad \text{...(ii)}$$

$$\Rightarrow \frac{6v_0\rho_0 g}{\pi r^2} = \frac{\Delta\ell'}{\ell_0}Y$$

$$\frac{\Delta\ell'}{4 \times 10^{-3}} = \frac{6v_0\rho_0 g}{8v_0\rho_0 g}$$

$$\Rightarrow \quad \Delta\ell' = \frac{6}{8} \times 4 \times 10^{-3} \text{ m}$$

$$\Rightarrow \quad \Delta\ell' = 3 \times 10^{-3} \text{ m} = 3 \text{ mm}$$

7. Answer (2)

$$\text{Stress} = \frac{F}{A} = \frac{4 \times 3.1\pi}{\pi \times (2 \times 10^{-3})^2} = 3.1 \times 10^6 \text{ N/m}^2$$

8. Answer (4)

$$\frac{1}{2} \cdot \left(\frac{YA}{L}\right)(\Delta l)^2 = \frac{1}{2} mv^2$$

$$\Rightarrow \quad Y = \frac{mv^2 L}{A(\Delta l)^2}$$

$$= \frac{0.02 \times 400 \times 0.42 \times 4}{\pi \times 36 \times 10^{-6} \times 0.04}$$

$$= 2.3 \times 10^6 \text{ N/m}^2$$

So, order is 10^6.

9. Answer (4)

$$\Delta L = \frac{FL}{YA}$$

$$\Rightarrow \quad \frac{L_A}{Y_A r_A^2} = \frac{L_B}{Y_B r_B^2}$$

$$\Rightarrow \quad r_A^2 = \sqrt{\frac{L_A}{L_B} \cdot \frac{Y_B}{Y_A}} \cdot r_B$$

$$= \sqrt{\frac{2 \times 2 \times 4}{3 \times 7}} \times 2 \text{ mm}$$

$$= \frac{4}{4.58} \times 2 = 1.7 \text{ mm}$$

10. Answer (3)

Corresponding to the stress (σ)

$$\text{Total elongation } \Delta l_{\text{net}} = \frac{\sigma L_1}{Y_1} + \frac{\sigma L_2}{Y_2}$$

$$\sigma = \Delta l \left(\frac{Y_1 Y_2}{Y_1 + Y_2}\right)$$

$$= 0.2 \times 10^{-3} \times \left(\frac{120 \times 60}{180}\right) \times 10^9$$

$$= 8 \times 10^6 \frac{\text{N}}{\text{m}^2}$$

11. Answer (2)

$$\text{Stress} = \frac{400}{\pi r^2} \leq 379 \times 10^6 \text{ N/m}^2$$

$$\Rightarrow \quad r^2 \geq \frac{400}{379 \times 10^6 \pi}$$

$$2r \geq 1.15 \text{ mm}$$

12. Answer (1)

$$\text{Energy desnsity} = \frac{1}{2} \text{ stress} \times \text{Strain}$$

$$\text{Energy density} = \frac{1}{2}\frac{F}{A} \times \frac{F}{AY}$$

$$\frac{u_1}{u_2} = \left(\frac{d_2}{d_1}\right)^4$$

$$\frac{d_1}{d_2} = (4)^{1/4}$$

$$\frac{d_1}{d_2} = \sqrt{2} : 1$$

13. Answer (3)

$$\frac{\Delta v}{v} = \frac{\Delta p}{B} = \frac{1}{20}$$

$$\frac{\Delta l}{l} = \frac{1}{3}\frac{\Delta p}{B} = \frac{1}{60}$$

$$\frac{\Delta l}{l} \times 100 = \frac{5}{3} = 1.67\%$$

14. Answer (4)

$$T = ml\omega^2$$

$$\sigma = \frac{T}{A} = \frac{ml\omega^2}{A}$$

$$\frac{ml\omega^2}{A} \leq 48 \times 10^7$$

$$\Rightarrow \quad \omega^2 \leq \frac{(48 \times 10^7)A}{ml}$$

$$\Rightarrow \quad \omega^2 \leq \frac{(48 \times 10^7)(10^{-6})}{10 \times 3} = 16$$

$$\Rightarrow \quad \omega_{\max} = 4 \text{ rad/s}$$

15. Answer (3)

$$\because \quad Y = \frac{9K\eta}{\eta + 3K}$$

$$\Rightarrow \quad K = \frac{Y\eta}{9\eta - 3Y}$$

16. Answer (2)

$$\Delta l = \frac{FL}{AY}$$

$$\frac{\Delta l_2}{\Delta l_1} = \frac{L_2}{A_2}\frac{A_1}{L_1}$$

$$\Delta l_2 = \left(\frac{L_2}{L_1}\right)\left(\frac{A_1}{A_2}\right)\ \Delta l_1 = 2 \times \frac{1}{4} \times 4 = 2\text{ cm}$$

17. Answer (1)

$$K = \frac{\Delta P}{\left(-\frac{\Delta V}{V}\right)}$$

$$\because \quad -\frac{\Delta V}{V} = \frac{\Delta\rho}{\rho}$$

$$\Rightarrow \quad K = \frac{\Delta P}{\left(\frac{\Delta\rho}{\rho}\right)}$$

$$\Rightarrow \quad \frac{\Delta\rho}{\rho} = \frac{\Delta P}{K}$$

$$\Rightarrow \quad \Delta\rho = \frac{\rho P}{K}$$

18. Answer (4)

$$\frac{\text{Stress}}{\text{Strain}} = \frac{\Delta P}{\left(\frac{\Delta V}{V}\right)}$$

$$= \frac{\rho g h}{\left(\frac{\Delta V}{V}\right)}$$

$$= \frac{10^3 \times 9.8 \times 2 \times 10^3}{\left(\frac{1.36}{100}\right)}$$

$= 1.44 \times 10^9$ N/m^2

19. Answer (32)

$$\Delta\ell = \frac{F\ell}{Ay}$$

$$\Rightarrow \quad \frac{\Delta\ell_A}{\Delta\ell_B} = \frac{\ell_A}{\ell_B} \times \frac{r_B^2}{r_A^2} \quad \Rightarrow \quad \frac{2}{4} = \frac{\ell_A}{\ell_B} \times 16$$

$$\Rightarrow \frac{\ell_A}{\ell_B} = \frac{1}{32} \quad \Rightarrow x = 32$$

20. Answer (3)

Let k be constant

$k(l_1 - l_0) = T_1$

$k(l_2 - l_0) = T_2$

$$\frac{T_1}{(l_1 - l_0)} = \frac{T_2}{(l_2 - l_0)}$$

$$l_0 = \left[\frac{T_1 l_2 - T_2 l_1}{T_1 - T_2}\right]$$

21. Answer (2)

$T_1 = k(l_1 - l_0)$ ...(i)

$T_2 = k(l_2 - l_0)$ ...(ii)

From (i) and (ii)

$$l_0 = \frac{l_1 T_2 - l_2 T_1}{T_2 - T_1}$$

22. Answer (3)

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

$$\Rightarrow \quad \frac{F}{\left(\frac{YA}{2L}\right)} = \frac{F}{\left(\frac{Y_1 A}{L}\right)} + \frac{F}{\left(\frac{Y_2 A}{L}\right)}$$

$$\Rightarrow \quad \frac{2L}{YA} = \frac{L}{Y_1 A} + \frac{L}{Y_2 A}$$

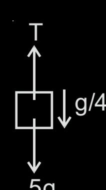
$$\Rightarrow \quad \frac{2}{Y} = \frac{L}{Y_1} + \frac{L}{Y_2}$$

$$\Rightarrow \quad Y = \frac{2Y_1 Y_2}{Y_1 + Y_2}$$

23. Answer (4)

$$\text{Acceleration, } a = \frac{5g - 3g}{8}$$

$$= \frac{2g}{8} = \frac{g}{4}$$

FBD of 5 kg 

$\Rightarrow \quad 5g - T = \frac{5g}{4}$

$T = \frac{15g}{4}$

Now, $\frac{T}{\pi r^2} \le \frac{24}{\pi} \times 10^2$

$r^2 \ge \frac{15g}{4 \times 24 \times 10^2} \Rightarrow r \ge \frac{5}{4 \times 10} m$

r_{min} = 12.5 cm

24. Answer (40)

$\sigma_1 = \frac{(m+30)g}{8 \times 10^{-7}} = 1.25 \times 10^9$

$\Rightarrow$ m + 30 = 100

m = 70

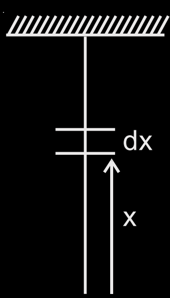
$\sigma_2 = \frac{(m+10)g}{4 \times 10^{-7}} = 1.25 \times 10^9$

m + 10 = 50

m = 40

$\Rightarrow$ 40 kg is safest maximum mass

25. Answer (2)



Tension in the rod at distance x is, $T = \frac{m}{l} xg$

$YA\frac{dy}{dx} = T$

$dy = \frac{T\,dx}{YA}$

$\int dy = \int \frac{mg}{AY} x dx$

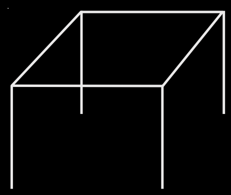
$y = \frac{mgl}{2AY}$

$= \frac{10 \times 0.20}{2 \times 100 \times 10^{-4} \times 2 \times 10^{11}}$

$= 0.50 \times 10^{-9}$

$= 5 \times 10^{-10}$

26. Answer (4)



Compressive force on each column $= \frac{mg}{4}$

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

Strain $= \frac{F}{AY}$

$= \frac{mg}{4\pi Y[r_2^2 - r_1^2]}$

$= \frac{50 \times 10^3 \times 9.8}{4\pi \times 2 \times 10^{11}[1^2 - (0.50)^2]}$

$= \frac{50 \times 10^3 \times 9.8}{6\pi \times 10^{11}}$

$= \frac{5 \times 9.8 \times 10^{-7}}{6\pi} = 2.6 \times 10^{-7}$

27. Answer (8)

$F = Y \alpha \Delta\theta \cdot A$

$= 2 \times 10^{11} \times 10^{-5} \times 400 \times 10 \times 10^{-4}$

$= 8 \times 10^5$ N

28. Answer (3)

$\because \quad B = \frac{\Delta P}{\left(-\frac{\Delta V}{V}\right)}$

$\Rightarrow \quad \Delta P = 3 \times 10^{10} \times (0.02)$

$= 6 \times 10^8$ N/m^2

29. Answer (25)

$$u_d = \frac{1}{2}\times Y\times(\text{strain})^2$$

$$= \frac{1}{2}\times\left(\frac{20}{10^{-10}}\right)\times\left(5\times10^{-4}\right)^2$$

$= 10^{11} \times 25 \times 10^{-8}$

$= 25 \times 10^3$ J/m^3

$= 25$ kJ/m^3

30. Answer (6)

$$\Delta l = \frac{M'gl}{2A\ y}$$

$\Rightarrow$ $\Delta l \propto g$

$$\Rightarrow \frac{g_p}{g_e} = \frac{\Delta l_p}{\Delta l_e} = \frac{6\times10^{-5}}{10\times10^{-5}}$$

$\Rightarrow$ g_p = 6 m/s^2 as g_e = 10 m/s^2

31. Answer (3)

$$y = \frac{FL}{A\Delta L}$$

$$\Rightarrow \Delta L = \frac{FL}{Ay}$$

$$\Rightarrow L_1 = L + \frac{(1g)L}{Ay} \qquad \ldots(i)$$

and $L_2 = L + \dfrac{(2g)L}{Ay} \qquad \ldots(ii)$

$\Rightarrow$ $L = 2L_1 - L_2$

32. Answer (5)

$$\frac{F/A}{\Delta L/L} = Y$$

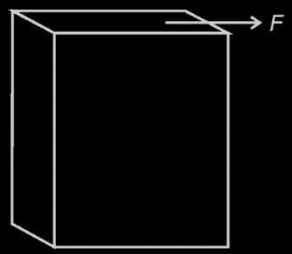
$$\Rightarrow \Delta L = \frac{FL}{AY}$$

$$\frac{\Delta L_2}{\Delta L_1} = \left(\frac{F_2}{F_1}\right)\times\left(\frac{L_2}{L_1}\right)\times\left(\frac{A_1}{A_2}\right)$$

$$= 4\times4\times\frac{1}{16} = 1$$

$\Delta L_2 = \Delta L_1$ = 5 cm.

33. Answer (48)



$$Y = \frac{Fl}{A\Delta l}$$

$$\Delta l = \frac{Fl}{YA}$$

$$= \frac{18\times10^4\times60\times10^{-2}}{25\times10^9\times60\times15\times10^{-4}}$$

$= 48 \times 10^{-6}$ m

34. Answer (4)

$\Delta l_s + \Delta l_c = 1.4$

$$\frac{Wl_s}{Y_sA} + \frac{Wl_c}{Y_c\times A} = 1.4\times10^{-3}$$

$$W = \frac{1.4\times10^{-3}}{\left[\frac{3.2}{2\times\left(\pi\times1.4\times10^{-3}\right)^2} + \frac{4.4}{1.1\times\left(\pi\times1.4\times10^{-3}\right)^2}\right]\frac{1}{10^{+11}}}$$

$W \simeq 154$ N

35. Answer (2)

$$Y = \frac{F\times l}{A\times\Delta l}$$

$$= \frac{1}{A}\times\frac{\text{Wire length}}{\frac{\text{Extension}}{\text{load}}}$$

$$Y = \frac{1}{A}\times\left(\frac{1}{0.25\times10^{-5}}\right)$$

$Y = 10^{11} \times 2$

$\Rightarrow x = 2$

36. Answer (3)

$A = 1\ \text{cm}^2$

$$Y = \frac{Fl}{A\Delta l}$$

$$F = \frac{YA\Delta l}{l} = \frac{2\times10^{11}\times10^{-4}\times l}{l}$$

$= 2 \times 10^7$ N

37. Answer (30)

$A = 4 \times 10^{-6}\ \text{m}^2$

$l = 0.5$ m

$m = 2$ kg

$v_b = 5$ m/s

$$T_b = mg + m\left(\frac{V_b^2}{l}\right)$$

$$= 20 + 2\times\frac{25}{\frac{1}{2}} = 120\ \text{N}$$

$$\frac{\Delta l}{l} = \frac{T_b}{A}\times\frac{1}{Y} = \frac{120}{4\times10^{-6}}\times10^{-11} = 30\times10^{-5}$$

38. Answer (1)

Young's modulus of matter depends on material of wire and is independent of the dimensions of the wire. As the material remains same so Young's modulus also remain same.

39. Answer (50)

$A = 10^{-4}\ \text{m}^2$

$$l = \frac{1}{2}\ \text{m}$$

$\sigma = 5 \times 10^8$

$$\frac{mv^2}{lA} = 5\times10^8$$

$$v = \sqrt{\frac{5\times10^8\times\frac{1}{2}\times10^{-4}}{10}} = 5 \times 10 = 50\ \text{m/s}$$

40. Answer (25)

$$\frac{\frac{F}{A}}{\frac{\Delta L}{L}} = Y$$

$$\Delta L = \frac{FL}{AY} = \frac{T_{avg}L}{AY} = \frac{MgL}{2AY}$$

$$= \frac{20\times10\times20}{2\times0.4\times2\times10^{11}} = \frac{4\times10^3\times10^{-11}}{4\times0.4}$$

$= 2.5 \times 10^{-8} = 25 \times 10^{-9}$

41. Answer (1)

$$\frac{W_1}{A_1} = \frac{W_2}{A_2}$$

$$\Rightarrow A_2 = \frac{W_2}{W_1}A_1$$

$$= \frac{25}{10}\times2.5\times10^{-4}$$

$= 6.25 \times 10^{-4}\ \text{m}^2$

❑ ❑ ❑