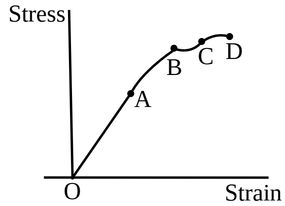
Q.1 To determine the young's modules by searle's method a student gets the stress v/s strain graph as shown in diagram. Which portion should give the best result –

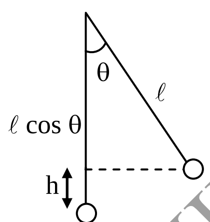


(A) BC (B) CD (C) AC (D) OA

[D]

Sol. It is proportional limit so OA is correct

Q.2 A sphere of mass M kg is suspended by a metal wire of length L and diameter d. When in equilibrium there is a gap of $\Delta\ell$ between the sphere and the floor. The sphere is gently pushed aside so that it makes an angle θ with the vertical. Find θ_{max} so that sphere fails to rub the Floor. Young's modulus of the wire is Y -



(A) $\sin^{-1}\left(1-\frac{Y\pi d^2\Delta\ell}{8MgL}\right)$

(B) $\tan^{-1}\left(1-\frac{Y\pi d^2\Delta\ell}{8MgL}\right)$

(C) $\cos^{-1}\left(1-\frac{Y\pi d^2\Delta\ell}{8MgL}\right)$

(D) none

Sol. **[C]**

$$Y = \frac{F\ell}{A\Delta\ell} = \frac{2Mg(1-\cos\theta)L}{\pi\frac{d^2}{4}\Delta\ell}$$

$$[\because \frac{Mv^2}{2} = Mg\ell(1-\cos\theta)$$

$$\Rightarrow \frac{Mv^2}{\ell} = 2Mg(1-\cos\theta)]$$

$$1-\cos\theta = \frac{Y\pi d^2\Delta\ell}{8Mg\ell} \Rightarrow \cos\theta = 1-\frac{Y\pi d^2\Delta\ell}{8Mg\ell}$$

Q.3 A copper wire of length 0.9 m and cross-sectional area 1.0 mm^2 is stretched by a load of 1kg. Young's modulus for copper is 1.2×10^{11} N/m^2 and g = $10 m/s^2$. The extension in wire in mm is -

(A) .013 (B) .075 (C) .11 (D) .13

Sol. **[B]** $Y = \frac{FL}{A\Delta L}$

$$\therefore \Delta L = \frac{FL}{YA} = \frac{1\times10\times0.9}{1.2\times10^{11}\times10^{-6}} = .075 \times 10^{-3}$$

m = .075 mm

Q.4 The ratio of diameters of two wires of same material is n : 1. The length of each wire is 4 m. On applying the same load, the increase in length of thin wire will be (n > 1) -

(A) n^2 times (B) n times

(C) 2n times (D) (2n + 1) times

Sol. **[A]**

$$Y = \frac{\frac{F}{a}}{\frac{\Delta\ell}{\ell}} = \frac{F\ell}{a\Delta\ell},\ Y = \frac{F\ell\times4}{\pi D^2\times\Delta\ell}$$

$$\text{or } \Delta\ell \propto \frac{1}{D^2} \qquad \text{or } \frac{\Delta\ell_2}{\Delta\ell_1} = \frac{D_1^2}{D_2^2} = \frac{n^2}{1}$$

Q.5 In order to twist one end of a wire, 2m long and 4 mm in diameter, though 45º, the torque required is -($\eta = 5 \times 10^{10}$ Nm^{-2})

(A) 0.49 Nm (B) 3.49 Nm

(C) 49 Nm (D) 4.9×10^{10} Nm

Sol. **[A]**

$$\tau = \frac{22\times5\times10^{10}(2\times10^{-3})^4\times22\times45}{7\times7\times180\times2\times2}\text{ Nm}$$

$$= 0.49\text{Nm}$$

Q.6 Given the following values for an elastic material: Young's modulus = 7×10^{10} Nm^{-2} and Bulk modulus = 11×10^{10} Nm^{-2} . The Poisson's ratio of the material is -

(A) 0.12 (B) 0.24

(C) 0.31 (D) 0.39

Sol. **[D]**

$K = \frac{Y}{3(1-2\sigma)}$ or $11 \times 10^{10} = \frac{7\times10^{10}}{3(1-2\sigma)}$

or $\frac{7}{33} = 1 - 2\sigma$

or $2\sigma = 1 - \frac{7}{33}$, $\sigma = \frac{26}{33} = 0.39$.

Q.7 A wire elongates by ℓ mm when a load W is hanged from it. If the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm) –

(A) 0 (B) $\ell/2$

(C) ℓ (D) 2ℓ **[C]**

Q.8 A rubber ball is taken to a 100 m deep lake and its volume changes by 0.1%. The bulk modulus of rubber is nearly –

(A) 1×10^6 N/m^2 (B) 1×10^8 N/m^2

(C) 1×10^7 N/m^2 (D) 1×10^9 N/m^2

[D]

Q.9 An aluminium and steel wire of same length and cross-section are attached end to end. The compound wire is hung from a rigid support and a load is suspended from the free end. Y of steel is (20/7) times of aluminium. The ratio of increase of length of steel wire to aluminium wire is –

(A) 20 : 3 (B) 10 : 7

(C) 7 : 20 (D) 1 : 7 **[C]**

Q.10 A gas undergoes a process in which the pressure and volume are related by VP^n = constant. The bulk modulus of the gas is –

(A) nP (B) $P^{1/n}$ (C) P/n (D) P^n

Sol. **[C]**

$VP^n = (V + \Delta V)(P + \Delta P)^n$

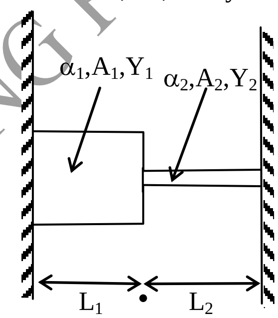
$VP^n = VP^n \left(1+\frac{\Delta V}{V}\right)\left(1+n\frac{\Delta P}{P}\right)$

$\therefore \frac{\Delta V}{V} = -n\frac{\Delta P}{P}$

$K = -\frac{\Delta P}{\Delta V / V} = \frac{P}{n}$

Q.11 Two elastic rods are joined between fixed supports as shown in the figure. Condition for no change in the lengths of individual rods with the increase of temperature is –

(α_1, α_2 = linear expansion coefficient, A_1, A_2 = Area of rods, Y_1, Y_2 = young modulus)



(A) $\frac{A_1}{A_2} = \frac{\alpha_1 Y_1}{\alpha_2 Y_2}$ (B) $\frac{A_1}{A_2} = \frac{L_1\alpha_1 Y_1}{L_2\alpha_2 Y_2}$

(C) $\frac{A_1}{A_2} = \frac{L_2\alpha_2 Y_2}{L_1\alpha_1 Y_1}$ (D) $\frac{A_1}{A_2} = \frac{\alpha_2 Y_2}{\alpha_1 Y_1}$

Sol. **[D]**

Since tension in the two rods will be same, hence

$A_1Y_1\,\alpha_1\Delta\theta = A_2Y_2\alpha_2\Delta\theta$

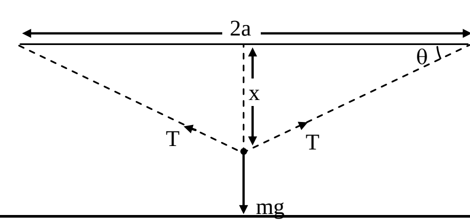
$\Rightarrow A_1Y_1\alpha_1 = A_2Y_2\alpha_2$

Q.12 A wire of length '2m' is clamped horizontally between two fixed support. A mass m = 5 kg is hanged from middle of wire. The vertical depression in wire in equilibrium is (young modulus of wire = 2.4×10^9 N/m^2, cross-sectional area = 1 cm^2) -

(A) 4.68 cm (B) 1.52 cm

(C) 1.12 cm (D) 0.58 cm **[A]**

Sol.



equation

$2T \sin\theta = mg$

$\Rightarrow 2.\left(\frac{YA}{a}\right) x \sin\theta . \sin\theta = mg$

$\Rightarrow \frac{2YA}{a} x. \frac{x^2}{a^2} = mg$

$\Rightarrow x = \left\{\frac{a^3 mg}{2YA}\right\}^{1/3}$

$= \left\{\frac{1m \times 5kg \times 10m/s^2}{2\times(2.4\times10^9 N/m^2)\times10^{-4}m^2}\right\}^{1/3}$

= 4.68 cm

Q.13 The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied -

(A) length = 50 cm, diameter = 0.5 mm

(B) length = 100 cm, diameter = 1 mm

(C) length = 200 cm, diameter = 2 mm

(D) length = 300 cm, diameter = 3 mm **[A]**

Sol. $Y = \frac{mg/A}{\ell/L} = \frac{mgL}{A\ell}$

$\ell = \frac{mgL}{YA}$

So $\ell \propto \frac{L}{d^2}$ hence (A)

Q.14 If the compressibility of water is σ per unit atmospheric pressure, then the decrease in volume (V) due to atmospheric pressure P will be -

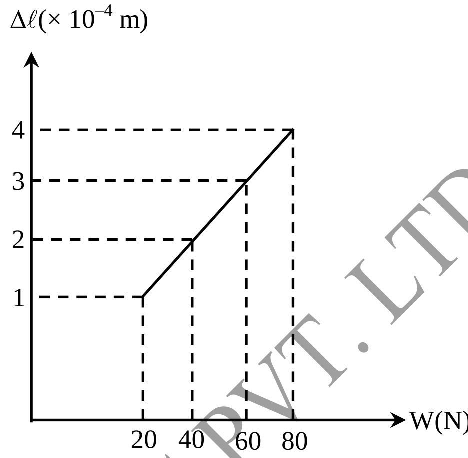
(A) $\sigma P/V$ (B) σPV

(C) σ/PV (D) $\sigma V/P$ **[B]**

Sol. $K = \frac{P}{\frac{\Delta V}{V}}$ or $\frac{1}{K} = \frac{\Delta V/V}{P}$

or $\sigma = \frac{\Delta V}{PV}$ or $\Delta V = \sigma PV$.

Q.15 The adjacent graph shows the extension (Δl) of a wire of length ℓ m suspended from the top of a roof at one end and with a load W connected to the other end. If the cross-sectional area of the wire is 10^{-6} m^2, calculate the Young's modulus of the material of the wire –



(A) 2×10^{11} N/m^2 (B) 2×10^{-11} N/m^2

(C) 3×10^{12} N/m^2 (D) 2×10^{13} N/m^2

[A]

Sol. $\Delta\ell = \left(\frac{\ell}{YA}\right).W$

i.e., graph is a straight line passing through origin

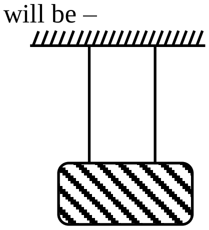
(as shown in question also), the slope of which is $\frac{\ell}{YA}$.

$\therefore$ Slope $= \left(\frac{\ell}{YA}\right)$

$\therefore Y = \left(\frac{\ell}{A}\right)\left(\frac{1}{\text{slope}}\right)$

$= \left(\frac{1.0}{10^{-6}}\right)\frac{(80-20)}{(4-1)\times10^{-4}} = 2.0 \times 10^{11}$ N/m^2.

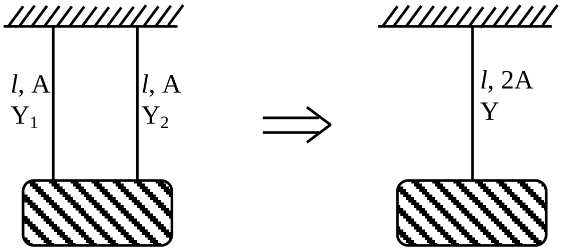
Q.16 Two wires of equal length and cross-section are suspended as shown. Their Young's modulii are Y_1 and Y_2 respectively. The equivalent Young's modulus will be –



(A) $Y_1 + Y_2$ (B) $\frac{Y_1 + Y_2}{2}$

(C) $\frac{Y_1 Y_2}{Y_1 + Y_2}$ (D) $\sqrt{Y_1 Y_2}$ **[B]**

Sol.



Equivalent spring constant of a wire is given by

$K = \frac{YA}{l}$

$K_{eq} = K_1 + K_2$

or $\frac{Y(2A)}{l} = \frac{Y_1 A}{l} + \frac{Y_2 A}{l}$

or $Y = \frac{Y_1 + Y_2}{2}$

Q.17 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]**

(A) F (B) 4 F
(C) 6 F (D) 9 F **[D]**

Sol. $\because \quad \Delta x = \frac{F.L}{A.Y}$

$\therefore \quad F = \frac{Y.A.\Delta x}{L}$ ………..(1)

Volume = A.L. = A'L' = constant

$\Rightarrow$ AL = 3AL'

$\Rightarrow$ L' = L/3 ……… (2)

From equation (1)

$\frac{F'}{F} = \frac{A'}{A}.\frac{L}{L'}$

$= 3 \times 3$

$\Rightarrow$ F' = 9F

So option (4) is correct.

Q.18 The rubber cord catapult has a cross-section area 1 mm^2 and total unstretched length 10 cm. It is stretched to 12 cm and then released to project a stone of mass 5 gm. Taking Young's modulus Y of rubber as 5×10^8 N/m^2, the velocity of projection will be -

(A) 20 cm/s (B) 20 m/s
(C) 2 m/s (D) none of these **[B]**

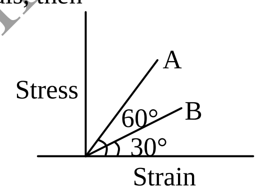
Sol. P.E. = $\frac{Y}{2}$ $(\text{strain})^2$ (AL) = K.E. = $\frac{1}{2}mv^2$

v = strain $\sqrt{\frac{Y}{m}AL}$

$= \frac{2}{10}\sqrt{\frac{5\times10^8}{5\times10^{-3}}\times10^{-6}\times0.1}$

= 20 m/s

Q.19 The stress versus strain graphs for wires of two materials A and B as shown is the figure. If Y_A and Y_B are the young's modulus of the materials, then-



(A) $Y_B = 2Y_A$ (B) $Y_A = Y_B$
(C) $Y_B = 3Y_A$ (D) $Y_A = 3Y_B$ **[D]**

Sol. $\frac{Y_A}{Y_B} = \frac{\tan 60°}{\tan 30°} = \frac{\sqrt{3}}{\frac{1}{\sqrt{3}}} = 3$

so $Y_A = 3Y_B$

Q.20 (a) Glass is more elastic than rubber
(b) Rubber is more elastic than glass
(c) Steel is more elastic than rubber
(d) Rubber is more elastic than steel
For the above statements–
(A) (a) and (b) are correct
(B) (a) and (c) are correct
(C) (b) and (c) are correct
(D) (b) and (d) are correct **[B]**

Q.21 Two similar balls, one of which is made of ivory while the other, of clay, are dropped from the same height, then–
(A) the ivory ball will bounce to a greater height
(B) the clay ball will bounce to a greater height
(C) both the balls will bounce to the same height
(D) the ivory ball will not at all bounce **[A]**

Q.22 What is the Young's modulus of elasticity for a perfectly rigid body ?

(A) infinity (B) zero

(C) 1 (D) – 1 **[A]**

Sol. Since strain is zero therefore Y is infinite.

Q.23 The longitudinal extension of any elastic material is very small. In order to have an appreciable change, the material must be in the form of -

(A) thin block of any cross section

(B) thick block of any cross section

(C) long thin wire

(D) short thin wire **[C]**

Q.24 The modulus of elasticity of a material does not depend upon–

(A) shape (B) temperature

(C) nature of material (D) impurities mixed

[A]

Q.25 A steel wire is stretched by 1 kg. wt. If the radius of the wire is doubled, its Young's modulus will–

(A) remain unchanged

(B) become half

(C) become double

(D) become four times **[A]**

Q.26 On withdrawing the applied force on some objects, the deformity caused gradually diminishes with time. This is called–

(A) elastic fatigue

(B) elastic limit

(C) coefficient of elasticity

(D) elastic after effect **[A]**

Q.27 On stretching some substances, permanent elongation is caused, because–

(A) they are perfectly elastic

(B) they are perfectly plastic

(C) more stress acts on them

(D) their strain is infinite **[B]**

Q.28 Out of the following whose elasticity is independent of temperature–

(A) steel (B) copper

(C) invar steel (D) glass **[C]**

Q.29 A cable that can support a load W is cut into two equal parts. The maximum load that can be supported by either part is–

(A) $\frac{W}{4}$ (B) $\frac{W}{2}$

(C) W (D) 2 W **[C]**

Q.30 On withdrawing the external applied force on bodies within the elastic limit, the body–

(A) regains its previous state very quickly

(B) regains its previous state after some time

(C) regain its previous state after a very long time

(D) does not regain its previous state **[B]**

Q.31 Elasticity is the property which is caused by–

(A) the applied deforming forces

(B) gravitational force

(C) nuclear forces

(D) inter-molecular forces **[D]**

Q.32 The effect of temperature on the value of Young's modulus of elasticity for various substances in general is–

(A) it increases with increase in temperature

(B) remains constant

(C) decrease with rise in temperature

(D) sometimes increases and sometimes decreases with temperature **[C]**

Q.33 The number of independent elastic constants of a solid is -

(A) 1 (B) 2

(C) 3 (D) 4 **[B]**

Q.34 The ratio of coefficient of isothermal and adiabatic elasticities of a gas is -

(A) γ (B) γ^2

(C) $1/\gamma$ (D) $1/\gamma^2$ **[C]**

Q.35 The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied–

(A) length 50 cm and diameter 0.5 mm

(B) length 100 cm and diameter 1 mm

(C) length 100 cm and diameter 2 mm

(D) length 300 cm and diameter 3 mm **[A]**

Q.36 An iron rod of length ℓ and of cross-section area A is heated from 0ºC to 100ºC. If the rod neither expands nor bends, then the developed F is proportional to–

(A) ℓ (B) ℓ^0

(C) ℓ^{-1} (D) A^{-1} **[B]**

Q.37 When a wire is stretched, an amount of work is done. What is the amount of work done in stretching a wire through 0.1 mm, if its length is 2m and area of cross-section, $10^{-6}m^2$ ($Y = 2 \times 10^{11}$ N/m^2)

(A) 5×10^{-1} J (B) 5×10^{-2} J

(C) 5×10^{-3} J (D) 5×10^{-4} J **[C]**

Q.38 Two wires of the same radius and material and having lengths in the ratio 8.9 : 7.6 are stretched by the same force. The strains produced in the two cases will be in the ratio -

(A) 1 : 1 (B) 1 : 7.6

(C) 8.9 : 1 (D) 1: 3.2 **[A]**

Sol. $Y = \frac{\text{stress}}{\text{strain}}$; Strain = $\frac{\text{stress}}{Y} = \frac{F/\pi r^2}{Y}$.

Q.39 An iron bar of length ℓ cm and cross section A cm^2 is pulled by a force of F dynes from ends so as to produce an elongation ℓ cm. Which of the following statement is correct–

(A) elongation is inversely proportional to length

(B) elongation is directly proportional to cross section A

(C) elongation is inversely proportional to A

(D) elongation is directly proportional to Young's modulus **[C]**

Q.40 Bulk modulus of water is 2×10^9 Nm^{-2}. The change in pressure required to increase the density of water by 0.1% is -

(A) 2×10^9 Nm^{-2} (B) 2×10^8 Nm^{-2}

(C) 2×10^6 Nm^{-2} (D) 2×10^4 Nm^{-2} **[C]**

Sol. The density would increase by 0.1% if the volume decrease by 0.1%,

$$K = \frac{\Delta P}{\frac{\Delta V}{V}}$$

$$\Rightarrow \Delta P = K\frac{\Delta V}{V} = 2 \times 10^9 \times \frac{0.1}{100} = 2 \times 10^6 \text{ Nm}^{-2}$$

Q.41 The 'σ' of a material is 0.20. If a longitudinal strain of 4.0×10^{-3} is caused, by what percentage will the volume change–

(A) 0.48 % (B) 0.32 %

(C) 0.24 % (D) 0.50 % **[C]**

Q.42 A cylinder is of length ℓ and diameter d. On stretching the cylinder, an increment $\Delta\ell$ in length and decrease Δd in diameter are caused. The Poisson ratio is–

(A) $\sigma = -\frac{\Delta\ell}{\ell}\times\frac{d}{\Delta d}$ (B) $\sigma = -\frac{\ell}{d}\times\frac{\Delta d}{\Delta\ell}$

(C) $\sigma = -\frac{\Delta\ell}{\ell}\times\frac{\Delta d}{d}$ (D) $\sigma = -\frac{\ell}{\Delta\ell}\times\frac{d}{\Delta d}$

[B]

Q.43 Steel is more elastic than rubber because for a given load the strain produced in steel as compared to that produced in rubber is–

(A) more

(B) less

(C) equal

(D) nothing can be said **[B]**

Q.44 In a wire stretched by hanging a weight from its end, the elastic potential energy per unit volume in terms of longitudinal strain σ and modulus of elasticity Y is -

(A) $\frac{Y\sigma^2}{2}$ (B) $\frac{Y\sigma}{2}$

(C) $\frac{2Y\sigma^2}{2}$ (D) $\frac{Y^2\sigma}{2}$

Sol. **[A]**

Energy density = $\frac{1}{2}$ × stress × strain,

$Y = \frac{\text{stress}}{\sigma}$ or stress = $Y\sigma$,

$\therefore$ Energy density = $\frac{1}{2}Y\sigma \times \sigma = \frac{Y\sigma^2}{2}$

Q.45 The formula for compressibility of a gas is–

(A) PdV/V (B) (1/P) dP/dV

(C) V . $\frac{dP}{dV}$ (D) $\frac{1}{V}.\frac{dV}{dP}$ **[D]**

Q.46 The potential energy of a metallic rod when it is compressed–

(A) increases (B) remains constant

(C) decreases (D) becomes infinite

[C]

Q.47 A spherical ball contracts in volume by 0.01% when subjected to a normal uniform pressure of 100 atmospheres. The bulk modulus of its material in dynes/ cm^2 is-

(A) 10×10^{12} (B) 100×10^{12}

(C) 1×10^{12} (D) 2.0×10^{11} **[C]**

Q.48 When 1 kg wt. is suspended from a wire, the increment produced is 2 mm, What will be the increment in lengths when 4 kg wt. is suspended from it-

(A) 4 mm (B) 8 mm

(C) 0.5 mm (D) 10 mm **[B]**

Q.49 On increasing temperature, the elasticity of a material-

(A) decreases

(B) increases

(C) sometimes increases and sometimes decreases

(D) remains same **[A]**

Q.50 Two wires, one of copper and the other of steel, are of same length and cross section. They are welded together to from a long wire. On suspending a weight at its one end, increment in length is found to be 3 cms. If Young's modulus of steel is double that of copper, the increment in steel wire will be-

(A) 1 cm (B) 2 cm

(C) 1.5 cm (D) 2.5 cm **[A]**

Q. 1 A steel rod with a length of 0.350 m and an aluminium rod with length of 0.250 m, both with same diameter, are placed end to end between rigid supports with no initial stress in the rods. The temperature of the rods is now raised by 60ºC. The length of combined rods remains the same, but the length of individual rods change.

$\alpha_S = 1.2 \times 10^{-5}/^{\circ}C$; $\alpha_A = 2.4 \times 10^{-5}/^{\circ}C$

$Y_S = 2 \times 10^{11}\ N/m^2$; $Y_A = 0.7 \times 10^{11}\ N/m^2$

Stress developed in each rod is......... $\times 10^7\ N/m^2$

[0012]

Q.2 A wire of length '2m' is clamped horizontally between two fixed support. A mass m = 5kg is hanged from middle of wire. The vertical and depression in wire (in cm) in equilibrium is (Young modulus of wire = $2.4 \times 10^9\ N/m^2$, cross-sectional area = $1\ cm^2$)

Sol.[5] At equilibrium

$2T \sin\theta = mg$

$\Rightarrow 2.\left(\frac{YA}{2a}\right) x \sin\theta . \sin\theta = mg$

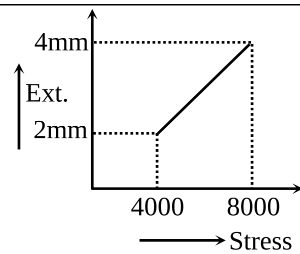
$\Rightarrow \frac{YA}{a}\ x.\ \frac{x^2}{a^2} = mg$

$\Rightarrow x = \left\{\frac{a^3 mg}{YA}\right\}^{\frac{1}{3}}$

$= \left\{\frac{1m \times 5kg \times 10\ m/s^2}{(2.4 \times 10^9\ N/m^2) \times 10^{-4} m^2}\right\}^{\frac{1}{3}}$

= 5 cm

Q.3 In determination of young modulus of elasticity of wire, a force is applied and extension is recorded. Initial length of wire is '1m'. The curve between extension and stress is depicted then young modulus of wire will be $K \times 10^9\ N/m^2$, where K is



Sol.[2] $\Delta\ell = \frac{F\ell}{\Delta y}$

$\frac{\Delta\ell}{F/A} = \frac{\ell}{y}$

$y = \frac{4000 \times 10^3}{2 \times 10^{-3}} = 2 \times 10^9\ N/m^2$