Exercise-1

Marked Questions can be used as Revision Questions.

OBJECTIVE QUESTIONS

Section (A) : Elastic behaviour longitudinal stress, young modulus

A-1. Sol. L = 4m

$Y = 9 \times 10^{10}$

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

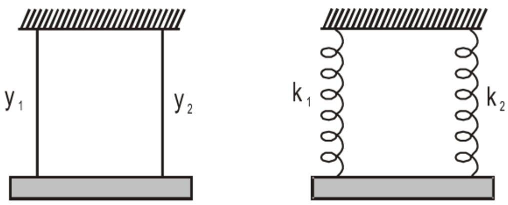
$F = AY\frac{\Delta\ell}{\ell}$

$= \pi(2x10^{-3})^2 \text{ x } 9 \times 10^9 \text{ x } \frac{1}{100}$

$= \pi \text{ x } 4 \text{ x } 10^{-6} \text{ x } 9 \times 10^7$

$= 360\ \pi$ N.

A-2.
Sol.

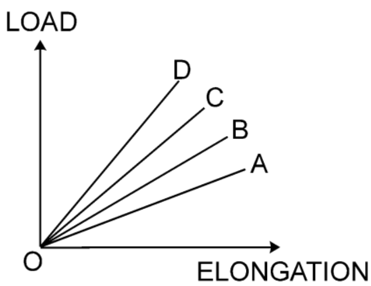


$K_{eq} = K_1 + K_2$

$\frac{Y2A}{\ell} = \frac{y_1A}{\ell} + \frac{y_2A}{\ell}$

$y = \frac{y_1 + y_2}{2}$

A-3.



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

$\frac{F}{\Delta\ell} = \frac{yA}{\ell}$ = slope $<$ $\Rightarrow$ y & ℓ are same for all then

slope $< \alpha$ A

Ans. (3)

Section (B) : Tangential stress and strain, shear modulus

B-1. Sol. $F = \eta A \frac{x}{h} = 0.4 \times 10^{11} \times 1 \times .005 \times \frac{.02 \times 10^{-2}}{1} = 4 \times 10^4$ N

Section (C) : Pressure and volumetric strain, bulk modulus of elasticity

C-1. Sol. $\frac{\Delta V}{V} = \frac{p}{B} = \frac{1 \times 10^5}{1.25 \times 10^{11}} = 8 \times 10^{-7}$

Section (D) : Elastic Potential Energy

D-1. Sol. $V = 1/2\ K(2)^2$

$V_1 = 1/2\ K(10)^2$

then $V_1 = 5V$

D-2. Sol. $K = \frac{Ay}{\ell}$, $K_2 = \frac{4Ay}{\ell/2} = 8K$

$2 = 1/2\ K(1)^2$; $U = 1/2(8K)(1)^2 = 4K$; $K = 4$, $U = 16$ J

Exercise-2

Marked Questions can be used as Revision Questions.

PART - I : OBJECTIVE QUESTIONS

1. Sol. $\frac{F}{A} = Y \frac{\Delta \ell}{\ell}$ If Y & $\frac{\Delta \ell}{\ell}$ are constant

$F = AY \frac{\Delta \ell}{\ell}$ $\Rightarrow$ $F \propto A$ $\Rightarrow$ $F' = 4F$

2. Sol. $\frac{p_1}{p_2} = \frac{m_1 v_1}{m_2 v_2}$, $m \propto r^3$, $v \propto r^2$ $\Rightarrow p \propto r^5$ then $\frac{p_1}{p_2} = \frac{1}{32}$

3. Sol. 46.4×10^{-6} atm $= \frac{1}{\beta}$

$\beta = \frac{1}{46.4 \times 10^{-6}} \Rightarrow \beta = \frac{P}{\Delta v / v} \Rightarrow \frac{\Delta v}{v} = \frac{\Delta p}{\beta} = 46.4 \times 10^{-6}$

4. Sol. depth = 200 m

$\frac{\Delta V}{V} = \frac{0.1}{100} = 10^{-3}$

density $= 1 \times 10^3$

g = 10

$\beta = \frac{\Delta p}{\Delta v / v} = \frac{hg\rho}{\Delta v / v}$ $\Rightarrow$ $\beta = 200 \times 10 \times 10^3 \times 1000 = 2 \times 10^9$

5. Sol. $V_T \propto r^2$

$V_T \propto \frac{\delta \frac{4}{3} \pi r^3}{r}$

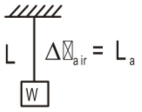
$V_T \propto \frac{m}{r}$

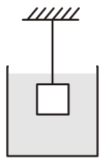
6. **Sol.** $\frac{r_1}{r_2} = \frac{1}{2}$

PE (per unit volume) $= \frac{1}{2y}\left(\frac{F}{A}\right)^2$

PE $\propto 1/A^2$

$\frac{PE_1}{PE_2} = \frac{A_2^2}{A_1^2} = 16 : 1$

8. **Sol.** 


$\Delta\ell_{water} = L_w$

$L_a = \frac{WL}{YA}$ $\quad L_w = \frac{\left[W - \frac{W}{\rho}\rho_W\right]}{YA} = \frac{W[1 - \frac{\rho_w}{\rho}]}{YA}$

$\frac{L_a}{L_w} = \left[1 - \frac{\rho_w}{\rho}\right]$

$\frac{\rho}{\rho_w} = \frac{L_a}{L_a - L_w}$

9. **Ans.** (i) $v = 5 \times 10^{-4}$ m/s

$v = \frac{2}{9\eta} r^2 \rho g$

$r^2 = \frac{5 \times 9 \times 18 \times 10^{-5} \times 10^{-4}}{2 \times 900 \times 10} = 9 \times 10^{-12}$

$r = 3 \times 10^{-6}$ m

(ii) $v \propto r^2$

$\frac{v_1}{v} = \frac{r_1^2}{r} = \frac{1}{4}$,

$v_1 = \frac{5}{4} = 1.25$ m/sec

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Asserton/ Reasonng

A-1. **Sol.** $Y = \frac{\text{Stress}}{\text{Strain}}$

(Strain)$_{steel}$ < (strain)$_{rubber}$

$Y = \frac{\text{i fr cy}}{\text{fod fr}}$

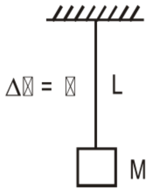
A-2. **Sol.** For incompressible fluid ΔV is zero.

Section (B) : Match the column

B-1. **Ans.** (1 → p); (B → q); (C → r); (D → q)

Sol. loss in PE = $Mg\ell$

PE âkl = $Mg\ell$



Elastic PE $= \frac{1}{2}Kx^2$

$= \frac{1}{2}\frac{Mg}{A} \times \frac{\ell}{L} \times AL$

$= MgL/2$

Heat $= MgL - Mg\,L/2$

$= Mg\ L/2$

Section (C) : One or More Than One Options Correct

C-1. **Sol.** Stress in wire B $= \frac{mg}{3\pi r_B^2}$

Stress in wire A $= \frac{4mg}{3\pi r_A^2}$

if $\frac{mg}{3\pi r_B^2} = \frac{4mg}{3\pi r_A^2}$ either wire will break.

C-2. **Sol.** $W = -\Delta U = \frac{1}{2}Kx^2 = \frac{1}{2}\frac{AY}{L}\ell^2$

Exercise-3

1. **Sol.** Elastic energy stored in the wire is

$U = \frac{1}{2}$ stress × strain × volume

$= \frac{1}{2}\frac{F}{A} \times \frac{\Delta l}{L} \times AL$

$= \frac{1}{2}F\Delta l$

$= \frac{1}{2} \times 200 \times 1 \times 10^{-3} = 0.1$

3. **Sol.** $g_{effective} = 0$

4. **Sol.** $u = \frac{1}{2}\frac{(stress)^2}{Y} = \frac{S^2}{2Y}$

5. **Ans:** (4)

Sol. $V_T \propto (\sigma_S - \sigma_L)$

$$\frac{0.2}{V} = \frac{19.5-1.5}{10.5-1.5}$$

V = 0.1 m/s

6. **Ans:** (2)
Sol. Tension in wire remains same

7. **Ans.** **[4]**
Sol. $mg = F_B + F_V$

$\rho_1 Vg = \rho_2 Vg + Kv_T^2$

$v_T = \sqrt{\frac{(\rho_1-\rho_2)Vg}{K}}$

8. **Sol.** **Ans. (3)**

$F = \frac{YAx}{\ell}$ and $F_2 = \frac{Y(3A)x}{(\ell/3)} = 9F$

9. **Sol.** $V\rho g = 6\pi\eta rv + v\rho_\ell g$

$Vg(\rho - \rho_\ell) = 6\pi\eta rv$

$Vg(\rho - \rho_\ell') = 6\pi\eta' rv'$

$V'\eta' = \frac{(\rho-\rho_\ell')}{(\rho-\rho_\ell)} \times v\eta$

$V' = \frac{(\rho-\rho_\ell')}{(\rho-\rho_\ell)} \times \frac{v\eta}{\eta'} = \frac{(7.8-1.2)}{(7.8-1)} \times \frac{10\times 8.5\times 10^{-4}}{13.2}$

$v' = 6.25 \times 10^{-4}$ cm/s.

Ans. **(1)**

10. **Sol.** $\frac{P}{\alpha\Delta\theta} = Y$

$P = Y\alpha\Delta\theta = 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100 = 2.2 \times 10^{8}$ Pa

Ans. **(1)**

11. **Ans.** **(1)**

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}}$

$T_M = 2\pi\sqrt{\frac{\ell+\Delta\ell}{g}}$ $\Delta\ell = \frac{Mg\ell}{AY}$

$\frac{T_M}{T} = \sqrt{\frac{\ell+\Delta\ell}{\ell}}$

$\left(\frac{T_M}{T}\right)^2 = 1 + \frac{\Delta\ell}{\ell}$

$\frac{1}{y} = \left(\left(\frac{T_M}{T}\right)^2 - 1\right) = 1 + \frac{Mg}{AY}$

$$\frac{1}{y} = \left(\left(\frac{T_M}{T}\right)^2 - 1\right)\frac{A}{Mg}$$

12. Sol. $\Delta P = \frac{mg}{a}$

$K = -\frac{\frac{mg}{A}}{\frac{4\pi r^2 dr}{\frac{4}{3}\pi r^3}}$

$\frac{dr}{r} = -\frac{mg}{3KA}$

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

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

The graph is straight line passing through origin the slope of which is $\frac{\ell}{YA}$.

$\therefore$ Slope $= \left(\frac{\ell}{YA}\right)$ $\therefore Y = \left(\frac{\ell}{A}\right)\left(\frac{1}{\text{slope}}\right) = \left(\frac{1.0}{10^{-6}}\right)\frac{(80-20)}{(4-1)\times 10^{-4}}$ = 2.0 × 10^{11} N/m^2

2. Sol. In equilibrium,
mg = qE
In absence of electric field,
mg = 6πηrv
⇒ qE = 6πqrv

$m = \frac{4}{3}\pi R r^3 d. = \frac{qE}{g}$

$\frac{4}{3}\pi\left(\frac{qE}{6\pi\eta v}\right)^3 d = \frac{qE}{g}$

After substituting value we get,
q = 8 × 10^{-19} C **Ans.**
Ans. (D)

3. Sol. $Y = \frac{\left(\frac{F}{A}\right)}{\frac{\Delta\ell_1}{L}}$ ...(i)

$Y = \frac{\left(\frac{F}{4A}\right)}{\frac{\Delta\ell_2}{2L}}$ ...(ii)

$\frac{\Delta \ell_1}{\Delta \ell_2} = 2$

Ans. **(C)**

4. **Sol.** $6\pi\eta rv + \rho_L Vg = \rho_0 Vg$

$$\frac{v_P}{v_Q} = \frac{(\rho_P V_P - \rho_L V_p)g}{6\pi\eta_p r_p} \times \frac{6\pi\eta_Q r_Q}{(\rho_Q V_Q - \rho_L V_Q)}$$

$$= \frac{r_p^3(8-0.8)}{\eta_p . r_p(8-1.6)} \times \frac{r_Q . \eta_Q}{r_Q^3}$$

$$= \left(\frac{r_p}{r_Q}\right)^2 \times \left(\frac{\eta_Q}{\eta_p}\right) \times \left(\frac{7.2}{6.4}\right) = 4 \times \frac{7.2}{6.4} \times \frac{2}{3} = 3$$

Additional Problems For Self Practice (APSP)

PART-I : PRACTICE TEST PAPER

1. **Sol.** Area = 1 cm2

$\Delta\ell = 1.1\,\ell - \ell$

Y = 2 x 1011

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

$F = AY\left(\frac{0.1\ell}{\ell}\right) = 1 \times 10^{-4} \times 2 \times 10^{11} \times 0.1$

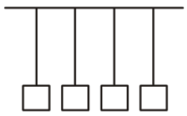
$= 2 \times 10^{6}$

2. **Sol.** T = 20 N

$\frac{2}{\pi} \times 10^{9} = \frac{20}{\pi r^2}$

$\Rightarrow$ $r = 10^{-4}$ m

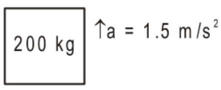
3. **Sol.** $\frac{\Delta\ell}{\ell} = \frac{F\ell}{AY}$



$\Delta\ell \propto \frac{\ell}{A}$

So, Ans. is (3)

4. **Sol.** $\frac{F}{A} = 7 \times 10^{7}$



$F = A \times 7 \times 10^{7}$

F – 2000 g = 2000 x a

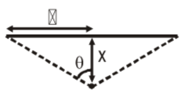
$(7 \times 10^{7})A = 2000\,(a + g)$

$A = \frac{2000}{7 \times 10^{7}}(10 + 1.5)$

$A = 3.28 \times 10^{-4}\ m^2$

5. **Sol.** Area = A

New length



$\ell' = 2\left(\sqrt{\ell^2 + x^2}\right)$

$\text{strain} = \frac{\Delta\ell}{\ell} = \frac{\ell' - 2\ell}{2\ell} \Rightarrow = \frac{2\ell\left(1 + \frac{x^2}{2\ell^2}\right) - 2\ell}{2\ell} = \frac{x^2}{2\ell^2}$

6. **Sol.** Bulk strain $= \dfrac{\Delta v}{v}$

$v = L^3 \quad \Rightarrow \quad \dfrac{\Delta v}{v} = 3\dfrac{\Delta L}{L}$

$\Rightarrow \quad \dfrac{\Delta v}{v} = 3 \times 0.02 \quad \Rightarrow \quad \dfrac{\Delta v}{v} = 0.06.$

7. **Sol.** $\dfrac{\Delta v}{v} = \dfrac{h\rho g}{B} \quad \Rightarrow \quad \dfrac{\Delta \rho}{\rho} = \dfrac{h\rho g}{B}$

$\Delta\rho = \dfrac{\rho^2 gh}{B}$.

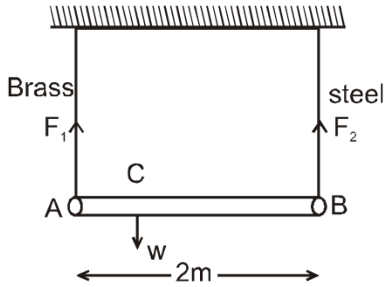
8. **Sol.** $F = mg$

$2 \times 10^{-5}\, v = \dfrac{4}{3}\pi r^3 \rho g$

$v = \dfrac{4 \times (1.5 \times 10^{-3})^3 \times 10^3 \times 10 \times 3.14}{3 \times 2 \times 10^{-5}} = 7$ m/s

9. **Sol.** $A_B = 0.2 \times 10^{-4}$

$A_S = 0.1 \times 10^{-4}$



$F_1 + F_2 = mg$

$\dfrac{F_1}{A_B} = \dfrac{F_2}{A_S}$ .....(1)

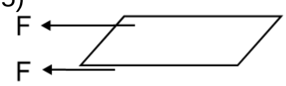
$F_1 x = F_2(2-x)$ ......(2)

$\dfrac{F_2 A_B x}{A_S} = F_2(2-x)$

$x = \dfrac{2A_S}{A_B + A_S} = 66.6$ cm

10. **Sol.** Velocity gradient $= \dfrac{0.5 \times 2}{2.5 \times 10^{-2}}$

Also, $F = 2\eta A\dfrac{dv}{dz} = 2 \times \eta \times (0.5)\dfrac{0.5}{1.25 \times 10^{-2}}$



$\Rightarrow \quad \eta = 2.5 \times 10^{-2}$ kg – sec/m^2

11. **Sol.** $B = -\frac{\Delta P}{\Delta V/V} = -\frac{V\ \Delta P}{\Delta V} = -\frac{1.5\times140\times10^{3}}{-0.2\times10^{-3}} = 1.05\times10^{9}$ Pa .

12. **Sol.** $F = \eta\frac{x}{h}$

$$\frac{500}{4\times16\times10^{-4}} = 2\times10^{6}\frac{x}{4\times10^{-2}} \Rightarrow x = \frac{5\times10^{-2}}{32}m = 0.156 \text{ cm}$$

13. **Sol.** $\ell_B = 2m$ $\ell_S = L$

$A_B = 2\ cm^2$ $A_S = 1\ cm^2$

$\Delta\ell_B = \Delta\ell_S$

$$\frac{F}{A_B}\frac{\ell_B}{y_B} = \frac{F}{A_S}\frac{\ell_S}{y_S}$$

$$L = \frac{A_S y_S}{A_B y_B}\ell_B = \frac{1}{2}\times\frac{2x10^{11}}{2x10^{-11}}\times 2 = 2$$

14. **Sol.** The gravitational force remains constant. The viscous force increases with increase in velocity. The net force decreases and finally becomes zero when terminal velocity is reached.

15. **Sol.** $\frac{r_1}{r_2} = b$

$\frac{\ell_1}{\ell_2} = a$

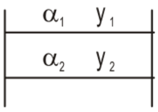
$\frac{y_1}{y_2} = c$

$\Delta\ell_1 = \frac{(3mg)\ell_1}{A_1y_1}$

$\Delta\ell_2 = \frac{(2mg)\ell_2}{A_2y_2}$

$$\frac{\Delta\ell_1}{\Delta\ell_2} = \frac{3\ell_1}{2\ell_2A_1y_1}\times A_2y_2 = \frac{3}{2}\frac{a}{b^2c} = \frac{3a}{2b^2c}$$

16. **Sol.**



$\frac{\alpha_1}{\alpha_2} = \frac{2}{6}$

$\because \frac{F}{A} = y\ \alpha\ \Delta\theta$ $\because \Delta\theta$ is same for both

$$\frac{F_1/A_1}{F_2/A_2} = \frac{y_1\alpha_1}{y_2\alpha_2} \qquad \frac{y_1}{y_2} = \frac{\alpha_2}{\alpha_1} = 3:1$$

17. **Sol.** $F = -\eta A \dfrac{dv}{dx}$

$\therefore \eta = -\dfrac{F}{A}\dfrac{dx}{dv}$

Writing the dimensions

$[\eta] = \dfrac{[MLT^{-2}]}{[L^2]}\dfrac{[L]}{[LT^{-1}]}$

$= [ML^{-1}T^{-1}]$

18. **Sol.** When strain is small, the ratio of the longitudinal stress to the corresponding longitudinal strain is called Young's molulus (Y) of the material of the body.

$Y = \dfrac{\text{stress}}{\text{strain}} = \dfrac{F/A}{\ell/L} = \dfrac{F.L}{\pi r^2 \ell}$

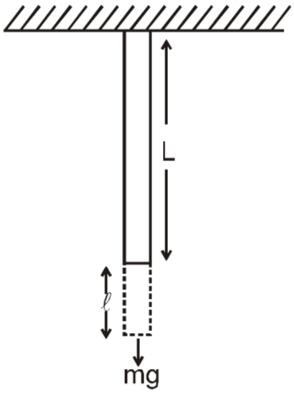
Given, $Y_1 = 7 \times 10^{10}$ N/m^2

$Y_2 = 12 \times 10^{10}$ N/m^2

$r_1 = \dfrac{D_1}{2} = \dfrac{3}{2}$mm

$r_2 = \dfrac{D_2}{2}$

$\therefore \dfrac{Y_2}{Y_1} = \left(\dfrac{D_1}{D_2}\right)^2$



$\dfrac{12 \times 10^{10}}{7 \times 10^{10}} = \left(\dfrac{3}{D_2}\right)^2$

$\Rightarrow \dfrac{3}{D_2} = \sqrt{\dfrac{12}{7}}$

$D_2 = 3\sqrt{\dfrac{7}{12}} \approx 2.3$ mm

19. **Sol.** Elastic energy stored in the wire is

$U = \dfrac{1}{2} \times$ stress $\times$ strain $\times$ volume

$= \dfrac{1}{2}\dfrac{F}{A} \times \dfrac{\Delta L}{L} \times AL$

$= \frac{1}{2}F\Delta L$

$= \frac{1}{2} \times 200 \times 1 \times 10^{-3} = 0.1$ J

20. **Sol.** Young's modulus (Y) = $\frac{F.\ell}{A\Delta\ell}$

$\therefore\ \Delta\ell = \frac{F.\ell}{YA} = \frac{F.\ell}{Y(\pi D^2/4)} = K\frac{\ell}{D^2}$

$\Delta\ell \propto \frac{\ell}{D^2}$

For first wire $\left(\frac{\ell}{D^2}\right) = \frac{100}{1\times10^{-2}} = 1 \times 10^4$

For second wire $\left(\frac{\ell}{D^2}\right) = \frac{50}{25\times10^{-4}} = 2 \times 10^4$

For third wire $\left(\frac{\ell}{D^2}\right) = \frac{200}{4\times10^{-2}} = 5 \times 10^3$

For fourth wire $\left(\frac{\ell}{D^2}\right) = \frac{300}{9\times10^{-2}} = \frac{1}{3} \times 10^4$

$= 3.33 \times 10^3$

As $\left(\frac{\ell}{D^2}\right)$ is maximum for second wire, therefore increase in its length will be maximum.

21. **Sol.** Potential energy stored in rubber is converted into kinetic energy.

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{\gamma A\ell^2}{L}$$

$$v = \sqrt{\frac{\gamma A\ell^2}{mL}}$$

$$= \sqrt{\frac{5\times10^8\times25\times10^{-6}\times(5\times10^{-2})^2}{5\times10^{-3}\times10\times10^{-2}}}$$

$= 250$ m/s

22. **Sol.** Force requied to increase the length of rod :

$$F = \frac{YA\ell}{L}$$

$$= \frac{9\times10^{10}\times\pi\times4\times10^{-6}\times0.1}{100} = 360\,\pi\ \text{N}$$

23. **Sol.** Volume elasticity coefficient :

$$B = \frac{\Delta p}{\Delta V/V} = \frac{h\rho g}{0.1/100}$$

$$= \frac{200\times10^3\times9.8}{1/1000}$$

$= 19.6 \times 10^8$

24. **Sol.** Work done to stretch the wire

$W = \frac{1}{2}F\ell = \frac{1}{2} \times 10 \times 0.5 \times 10^{-3}$

$= 2.5 \times 10^{-3}$ J

Work done to stretch the wire by 1.5 mm, now total extension in 2 mm and force required for this is 40N.

$W' = \frac{1}{2}(4F)(4\ell) - \frac{1}{2}F\ell = \frac{15}{2}F\ell = 15 \times 2.5 \times 10^{-3}$ J

Ratio of both the workdone = 1 : 2

25. **Sol.** Poission's ratio = $\frac{\text{Lateral strain}}{\text{Longitudinal strain}}$

$\therefore$ Lateral strain = $0.4 \times \frac{0.05}{100}$

= 0.02%

26. **Sol.** Tensile force on each surface = $\frac{F}{Y}$

Lateral strain due to other two forces acting on perpendicular surfaces = $\frac{-2\sigma F}{Y}$

Total increase in length = $(1-2\sigma)\frac{F}{Y}$

27. **Sol.** Dueto tension intermolecular distance will increase. So potential energy will increase and intermolecular force between molecules will decrease. This change in potential energy will produce heat by which temperature will increase.

PART-II : PRACTICE QUESTIONS

7. **Sol.** **(4)**

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

$\frac{K_1}{K_2} = \frac{Y_1}{Y_2}$

$T = 2\pi\sqrt{\frac{m}{K}}$

$\frac{T_1}{T_2} = \sqrt{\frac{K_2}{K_1}} = \sqrt{\frac{Y_2}{Y_1}}$

$\frac{T_1}{T_2} = \sqrt{\frac{3}{2}}$

8. A stress of 10^6 N/m^2 is required for breaking a material. If the density of the material is 3×10^3 kg/m^3,

Sol. $F = (\sigma)\pi r^2$

$\pi r^2\rho\ell g = \sigma\pi r^2$

$\ell = \left(\frac{\sigma}{\rho g}\right) = 33.3$ m.

9. **Sol.** Strain developed :
$\varepsilon = \alpha\,\Delta T = (12 \times 10^{-6})\,(50) = 6 \times 10^{-4}$
Strain will be **negative**, as the rod is in a compressed state.
$\varepsilon = \alpha\,\Delta T = (12 \times 10^{-6})\,(50) = 6 \times 10^{-4}$

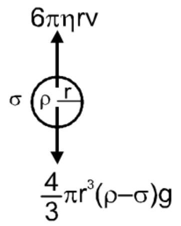
10. **Sol.** $ma = T - mg$; $\frac{T}{A} = 10^9$
$2 \times 10^3 \times a = 10^5 - 2 \times 10^3\, g$
$2 \times 10^3\, a = 8 \times 10^4$
$a = 40$ m/s^2 .

11. **Sol.** **[Easy]**
Bulk modulus of elasticity at constant temperature

$$B = -\frac{dP}{dV/V} = -V\left(\frac{dP}{dV}\right)_T = +P = \frac{nRT}{V}$$
$$= \frac{1 \times R \times 400}{1^3} = 400\,R$$

12. **Sol.** η and Y are properties of material.
These coefficients are independent of geometry of body.

13. **Sol.**



$6\pi\eta rv = \frac{4}{3}\pi r^3\,(\rho - \sigma)g$
$v \propto r^2$
$V = \frac{4}{3}\pi r^3$
$r \propto V^{1/3}$
$r^2 \propto V^{2/3}$
$v \propto V^{2/3}$

$$\frac{v_1 \propto V^{2/3}}{v_2 \propto (2V)^{2/3}}$$
$$\frac{v_1}{v_2} = \left(\frac{1}{2}\right)^{2/3}$$

$v_2 = v\, 2^{2/3}$.

14. **Sol.** $T = \frac{F}{L}$ ....(i)
$F = \eta A \frac{dv}{dx} \equiv \eta L^2 \frac{V}{L} = \eta LV$

$\eta = \frac{F}{LV}$ ....(ii)

From (i) (ii),

$\left[\frac{F}{\eta}\right] \equiv [V]$.

15. **Sol.** $K = \frac{AY}{\ell} = \frac{4 \times 10^{-4} \times 2 \times 10^{10}}{4} = 2 \times 10^6$

$\omega = \sqrt{\frac{K}{m}} = 100$

16. **Sol.** $W(h + x) = 1/2\ kx^2$

$100(0.99 + x) = \frac{1}{2} \times 2 \times 10^6 \times x^2$

$10^4 x^2 - x - 0.99 = 0$

$100\ x\ (100x - 1) + 0.99\ (100\ x - 1) = 0$

$x = \frac{1}{100}$ m = 1 cm

17. **Sol.** $x = \frac{PL}{AY}$

$\sigma = \frac{P}{A} = \frac{xY}{L} = \frac{10^{-2} \times 2 \times 10^{10}}{4} = 5 \times 10^7$ N/m^2

18. **Sol.** $K_1 = 10^6$, $K_2 = 2 \times 10^6$

$K_{eq} = \frac{2 \times 10^6 x 10^6}{3 \times 10^6} = \frac{2}{3} \times 10^6$

$\omega = \sqrt{\frac{2 \times 10^6}{3 \times 600}} = \frac{100}{3}$

19. **Sol.** Total weight = 1000 + w

weight on each rod = $\frac{1000 + w}{4}$

stress = $\frac{1000 + w}{4 \times 4 \times 10^{-4}} = 9 \times 10_6$

$\Rightarrow$ w = 14400 – 1000 = 13400 N

No. of persons are = $\frac{1340}{50} = 26$