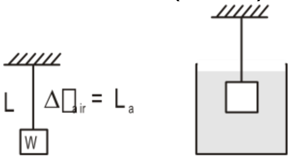
# HINTS & SOLUTIONS
## TOPIC : ELASTICITY & VISCOSITY
## EXERCISE # 1

**SECTION (A)**

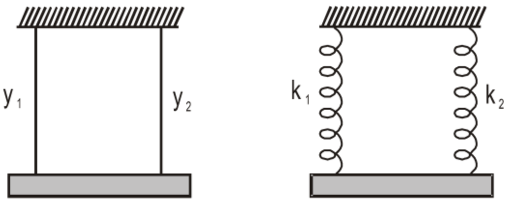
**1.** L = 4m
$Y = 9 \times 10^{10}$
$\frac{F}{A} = Y\frac{\Delta\ell}{\ell}$
$F = AY\frac{\Delta\ell}{\ell} = \pi(2x10^{-3})^2 \text{ x } 9 \times 10^9 \text{ x } \frac{1}{100} = \pi \text{ x } 4 \text{ x } 10^{-6} \text{ x } 9 \times 10^7 = 360\ \pi$ N.

**2.** 


$\Delta\ell_{water} = L_w$

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

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

**3.** 

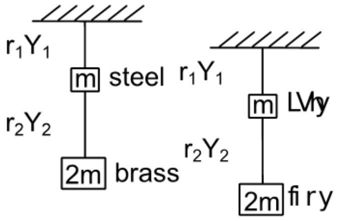

$k_{eq} = k_1 + k_2$
$\frac{Y2A}{\ell} = \frac{Y_1A}{\ell} + \frac{Y_2A}{\ell}$ $\Rightarrow$ $Y = \frac{Y_1 + Y_2}{2}$

**4.** $\frac{F/A}{\Delta\ell/\ell} = Y$ $\Rightarrow$ $\frac{F}{\Delta\ell} = \frac{YA}{\ell}$ = slope $\Rightarrow$ Y & $\ell$ are same for all them
slope $\alpha$ A

**5.** $\frac{F}{A} = Y\frac{\Delta\ell}{\ell}$ If $Y$ $\frac{\Delta\ell}{\ell}$ & are constant
$F = AY\frac{\Delta\ell}{\ell}$ $\Rightarrow$ $F \propto A$ $\Rightarrow$ F' = 4F

**6.** $\ell_B$ = 2m $\ell_S$ = L
$A_B = 2\ cm^2$ $A_S = 1\ cm^2$
$\Delta\ell_B = \Delta\ell_S$
$\frac{F}{A_B}\frac{L_B}{Y_B} = \frac{F}{A_S}\frac{L_S}{Y_S}$ $\Rightarrow$ $L = \frac{A_SY_S}{A_BY_B} L_S = \frac{1}{2} \text{ x } \frac{2x10^{11}}{2x10^{-11}} \text{ x } 2 = 2$

**7.** $\frac{\ell_1}{\ell_2} = a$ $\frac{r_1}{r_2} = b$
$\frac{Y_1}{Y_2} = c$




$\Delta\ell_1 = \dfrac{(3mg)\ell_1}{A_1Y_1}$

$\Delta\ell_2 = \dfrac{(2mg)\ell_2}{A_2Y_2}$

$\dfrac{\Delta\ell_1}{\Delta\ell_2} = \dfrac{3\ell_1}{2\ell_2 A_1Y_1}\times A_2Y_2 = \dfrac{3}{2}\dfrac{a}{b^2c} = \dfrac{3a}{2b^2c}$

**8.** Breaking stress is characteristic property of wire. Independent to shape and size.

**9.** $Y = \dfrac{k}{r_0} = \dfrac{7}{3\times10^{-10}} = 2.33\times10^{10}\ N/m^2$

**10.** using $Y = \dfrac{\frac{mg}{A}}{\frac{\Delta\ell}{\ell}}$

we get $= 19.6\times10^{10}\ N/m^2$

**11.** $\Delta L = \dfrac{FL}{YA} \Rightarrow \Delta L = \dfrac{mgL}{YA}$

**12.** $\Delta\ell = \left(\dfrac{\ell}{YA}\right)\cdot W$

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

$\therefore$ Slope $= \left(\dfrac{\ell}{YA}\right)$ $\quad\therefore Y = \left(\dfrac{\ell}{A}\right)\left(\dfrac{1}{slope}\right) = \left(\dfrac{1.0}{10^{-6}}\right)\dfrac{(80-20)}{(4-1)\times10^{-4}} = 2.0\times10^{11}\ N/m^2$

**13.** $Y = \dfrac{\left(\frac{F}{A}\right)}{\frac{\Delta L_1}{L}}$ ...(i)

$Y = \dfrac{\left(\frac{F}{4A}\right)}{\frac{\Delta L_2}{2L}}$ ...(ii)

$\dfrac{\Delta L_1}{\Delta L_2} = 2$

**14.** Young's modulus of a substance is independent of dimension s of wire.

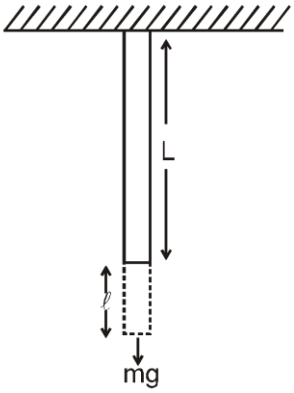
**15.** When strain is small, the ratio of the longitudinal stress to the corresponding longitudinal strain is called Young's molulus (Y) of the material of the body.

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

Given, $Y_1 = 7\times10^{10}\ N/m^2$

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

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




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

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

$\frac{12\times10^{10}}{7\times10^{10}} = \left(\frac{3}{D_2}\right)^2 \quad \Rightarrow \quad \frac{3}{D_2} = \sqrt{\frac{12}{7}}$

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

**16.** 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.

**17.** Potential energy stored in rubber is converted into kinetic energy.

$\frac{1}{2}mv^2 = \frac{1}{2}\frac{YA(\Delta L)^2}{L}$

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

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

= 250 m/s

**18.** Force requied to increase the length of rod :

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

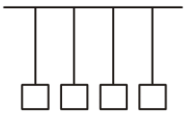
$$= \frac{9\times10^{10}\times\pi\times4\times10^{-6}\times0.1}{100} = 360\,\pi \text{ N}$$ U

**19.** T = 20 N

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

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

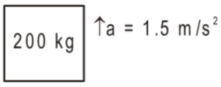
**20.** $\frac{\Delta\ell}{\ell} = \frac{F}{AY}$



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

So, Ans. is (3)

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




F = A × 7 × $10^{7}$

F – 2000 g = 2000 x a

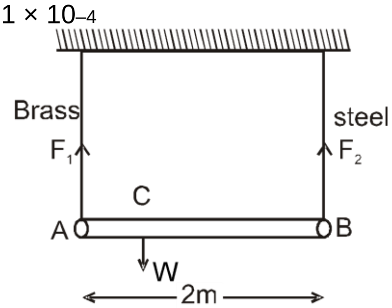
(7 x $10^{7}$)A = 2000 (a + g)

$A = \frac{2000}{7\times10^{7}}(10 + 1.5)$

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

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

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




$F_1 + F_2 = mg$

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

$F_1x = F_2(2–x)$ ......(2)

$\frac{F_2A_Bx}{A_S} = F_2(2-x)$

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

**23.** $\ell_B = 2m$ $\ell_S = L$

$A_B = 2\ cm^2$

$A_S = 1\ cm^2$

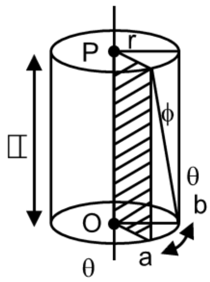
$\Delta\ell_B = \Delta\ell_S$

$$\frac{F}{A_B}\frac{\ell_B}{Y_B} = \frac{F}{A_S}\frac{\ell_S}{Y_S}$$

$$L = \frac{A_S Y_S}{A_B Y_B}\ell_B = \frac{1}{2} \times \frac{2\times10^{11}}{2\times10^{-11}} \times 2 = 2$$

**SECTION (B)**

**1.** $F = \eta A \frac{x}{h} = 0.4 \times 10^{11} \times 1 \times .005 \times \frac{.02\times10^{-2}}{1} = 4\times10^{4}$ N

**2.** 


Arc ab is in two circles with centers at O and P so $r\theta = \ell\phi$

$\Rightarrow \phi = \frac{r\theta}{\ell}$

**3.** $\frac{F}{A} = \eta\frac{x}{h}$

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

**4.** Poission's ratio = $\frac{\text{Lateral strain}}{\text{Longitudinal strain}}$ ∴ Lateral strain = $0.4\times\frac{0.05}{100}$ = 0.02%

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

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

**SECTION (C)**

**1.** $\frac{\Delta V}{V} = \frac{p}{B} = \frac{1\times10^{5}}{1.25\times10^{11}} = 8\times10^{-7}$

**2.** $46.4 \times 10^{-6}$ atm $= \frac{1}{K}$

$K = \frac{1}{46.4\times10^{-6}}$ ; $B = \frac{P}{\Delta v / v} \Rightarrow \frac{\Delta v}{v} = \frac{\Delta p}{K} = 46.4 \times 10^{-6}$

**3.** depth = 200 m

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

density = $1 \times 10^{3}$

g = 10

$B = \frac{\Delta p}{\Delta v / v} = \frac{hg\rho}{\Delta v / v}$ ⇒ B = 200 x 10 x $10^3$ x 1000 = 2 x $10^9$

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

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

PE ∝ $1/A^2$

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

**5.** Twisting couple C = $\frac{\pi\eta r^4\theta}{2\ell}$

If material and length of the wires A and B are equal and equal twisting couple are applied then

$\theta \propto \frac{1}{r^4} \therefore \frac{\theta_1}{\theta_2} = \left(\frac{r_2}{r_1}\right)^4$

**6.** Angle of shere $\phi = \frac{r\theta}{L} = \frac{4\times10^{-1}}{100}$ × 30° = 0.12°

**7.** $r\theta = L\phi \Rightarrow 10^{-2} \times 0.8 \times = 2 \times \phi \Rightarrow \phi = 0.004$

**9.** ∵ arc = rθ = Lφ ⇒ $\phi = \frac{r\theta}{L}$

$\phi = \frac{30^\circ \times 0.4}{100}$ = 0.12°

**10.** 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 × $10^8$ N/$m^2$

**11.** $\frac{\Delta V}{V} = \frac{h\rho g}{B}$ ⇒ $\frac{\Delta\rho}{\rho} = \frac{h\rho g}{B}$

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

**12.** $B = -\frac{\Delta P}{\Delta V / V} = -\frac{V\,\Delta P}{\Delta V} = -\frac{1.5\times140\times10^3}{-0.2\times10^{-3}}$ = 1.05 × $10^9$ Pa .

**SECTION (D)**

**1.** V = 1/2 k$(2)^2$

$V_1$ = 1/2 k$(10)^2$

then $V_1$ = 25V

**2.** $U = \frac{1}{2}kx^2 = \frac{L}{2}\frac{AY}{\ell}$ ⇒ $\frac{U_2}{U_1} = \frac{A_2}{A_1}\frac{\ell_1}{\ell_2} = \frac{\pi r_2^2\ell_1}{\pi r_1^2\ell_2} = \frac{(2)^2}{\ell/2} = 8$

∴ $U_2 = 8U_1$ = 16 J

**3.** Y = $\frac{\text{Stress}}{\text{Strain}}$ = Constant

It depends only on nature of material.

**5.** Work done = $\frac{1}{2}\times F\ell = \frac{Mg\ell}{2}$

**6.** Energy stored = $\frac{1}{2}$ stress × strain × volume

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

$\therefore \frac{U}{V} = \frac{1}{2}S\times\frac{S}{Y} = \frac{1}{2}\frac{S^2}{Y}$

**8.** U = $\frac{F^2}{2k} = \frac{T^2}{2k}$

**10.** W = $\frac{YA\ell^2}{L}$ = $\frac{2\times10^{10}\times10^{-6}\times\left(10^{-3}\right)2}{2\times50\times10^{-2}}$ $2\times10^{-2}$ J

**11.** U = $\frac{1}{2}$ Y $(\text{strain})^2$ Volume

U = 0.075 J

**13.** U = $\frac{1}{2}$ Y $(\text{strain})^2$ Volume

**14.** Work done = $\frac{1}{2}$ mgh = $\frac{1}{2}$ × 5 ×10 × 3 = 75J

**15.** Work done = $\frac{1}{2}$ mgh = $\frac{1}{2}$ × 5 ×10 × 3

**16.** Elastic energy stored in the wire is

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

= $\frac{1}{2}\frac{F}{A}\times\frac{\Delta L}{L}\times AL$ = $\frac{1}{2}F\Delta L$ = $\frac{1}{2}$ × 200 × 1 × $10^{-3}$ = 0.1 J

**17.** Elastic energy stored in the wire is

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

= $\frac{1}{2}\frac{F}{A}\times\frac{\Delta l}{L}$ ×AL = $\frac{1}{2}$ F$\Delta l$ = $\frac{1}{2}$ × 200 ×1 ×$10^{-3}$ = 0.1

**18.** u = $\frac{1}{2}\frac{(\text{stress i frcy})^2}{Y} = \frac{S^2}{2Y}$

**19.** Tension in wire remains same

**SECTION (E)**

**1.** (i) v = 5 × $10^{-4}$ m/s

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

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

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

(ii) $v \propto r^2$

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

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

**2.** $v_t = \dfrac{2}{9}\dfrac{r^2(\rho - \sigma)}{\eta} \propto r^2$

**3.** $mg - 6\pi\eta rv = ma$

When $mg = 6\pi\eta rv$, $F = 0$

**4.** No medium is present in vacuum so $\eta = 0$

**5.** 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.

**6.** $V_T \ \alpha \ r^2$

$V_T \ \alpha \ \dfrac{\rho \frac{4}{3}\pi r^3}{r}$

$V_T \ \alpha \ \dfrac{m}{r}$

**7.** Theortical

**9.** $m\dfrac{g}{2} = mg - F_B - F_V$

$F_V + F_B = \dfrac{1}{2}mg$

$6\pi\eta rv + \sigma \dfrac{4}{3}\pi r^3 g = \dfrac{1}{2}\rho\dfrac{4}{3}\pi r^3 g$

$v = \dfrac{r^2 g}{9\eta}(\rho - 2\sigma)$

**10.** In equilibrium,

$mg = qE$

In absence of electric field,

$mg = 6\pi\eta rv$

$\Rightarrow$ $qE = 6\pi qrv$

$m = \dfrac{4}{3}\pi r^3\rho. = \dfrac{qE}{g}$ $\Rightarrow$ $\dfrac{4}{3}\pi\left(\dfrac{qE}{6\pi\eta v}\right)^3\rho = \dfrac{qE}{g}$

After substituting value we get,

$q = 8 \times 10^{-19}$ C **Ans.**

**11.** A liquid has no length and no shape, but it has only definite volume and so, it possesses only bulk modulus.

**12.** $F = -\eta A \frac{dv}{dx}$ $\therefore \eta = -\frac{F}{A}\frac{dx}{dv}$

Writing the dimensions

$[\eta] = \frac{[MLT^{-2}]}{[L^2]}\frac{[L]}{[LT^{-1}]} = [ML^{-1}T^{-1}]$

**14.** $g_{effective} = 0$

**15.** $V_T \; \alpha \; (\sigma_S - \sigma_L)$

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

V = 0.1 m/s

**16.** $mg = F_B + F_V$

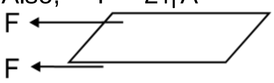
$\rho_1 Vg = \rho_2 Vg + Kv_T^2$

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

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

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

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




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

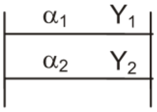
**19.** F = mg

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

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

## EXERCISE # 2

**1.**




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

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

$\frac{F_1/A_1}{F_2/A_2} = \frac{Y_1\alpha_1}{Y_2\alpha_2}$ $\Rightarrow$ $\frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = 3 : 1$

**2.** $mg - F_V - F_{up} = ma = 0$

$mg = F_V + F_{up}$ ... (i)

Now $F - mg - F_V - F_{up} = 2mg - mg - F_V - F_{up} = mg - F_V - F_{up} = 0$

$\Rightarrow$ Acceleration in second case = 0

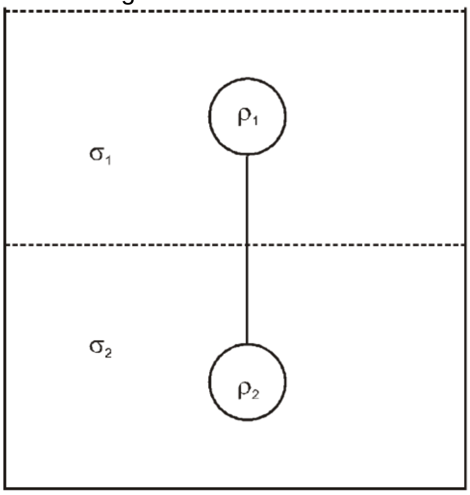
$\therefore$ ball will move upward with constant speed = 10 cm/s

**3.** For floating

$(\rho_1 + \rho_2)V = (\sigma_1 + \sigma_2)V$

$\rho_1 + \rho_2 = \sigma_1 + \sigma_2$

since strings in taut so




$\rho_1 < \sigma_1$ $\rho_2 > \sigma_2$

$V_P = \frac{2}{9}\frac{r^2(\sigma_2 - \rho_1)g}{\eta_2}$

$V_Q = \frac{2}{9}\frac{(\sigma_1 - \rho_2)g}{\eta_1}$

since $\sigma_2 - \rho_1 = -(\sigma_1 - \rho_2)$

$\left|\frac{V_P}{V_Q}\right| = \frac{\eta_1}{\eta_2}$

$\vec{V}_P . \vec{V}_Q < 0$ because $V_P$ and $V_Q$ are opposite

**4.** Area = 1 $cm^2$

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

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

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

$F = AY\left(\frac{0.1\ell}{\ell}\right) = 1 \times 10^{-4} \times 2 \times 10^{11} \times 0.1 = 2 \times 10^6$

**5.** Bulk strain = $\frac{\Delta V}{V}$

$V = L^3 \Rightarrow \frac{\Delta V}{V} = 3\frac{\Delta L}{L}$

$\Rightarrow \frac{\Delta V}{V} = 3 \times 0.02 \Rightarrow \frac{\Delta V}{V} = 0.06.$

## EXERCISE # 3
### PART - I

**1.** F = Kx

$F = \frac{YA}{L} \times \Delta L$

$\Delta L \propto \frac{L}{A} \propto \frac{L}{D^2}$

$\Delta L_1 \propto \frac{100}{1^2} \propto 100$

$$\Delta L_2 \propto \frac{200}{2^2} \propto 50$$

$$\Delta L_3 \propto \frac{300}{3^2} \propto \frac{100}{3}$$

$$\Delta L_4 \propto \frac{50}{\frac{1}{4}} \propto 200$$

Here $\Delta L_4$ correct.

**2.** $V = A\ell$

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

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

$$\Delta \ell = \frac{F\ell}{YA} = \frac{F}{Y}.\frac{\ell\ell}{V}$$

$$\Delta \ell = \frac{F}{YV}\ell^2$$

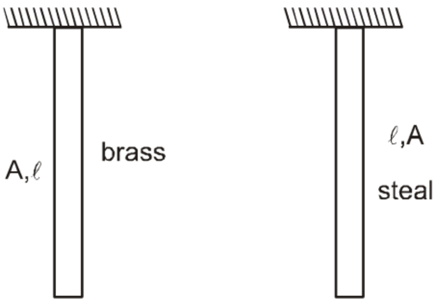
$$\Delta \ell \propto \ell^2$$

**3.** $B = \frac{\Delta P}{(\Delta v / v)}$ $\Rightarrow$ compressibility $= \frac{1}{B} = \frac{\Delta V}{V\Delta P}$

So, Fractional compression $\frac{\Delta V}{V} = \Delta P \times \left(\frac{1}{B}\right)$

$= 45.4 \times 10^{-11} \times 10^3 \times 10 \times 2700 = 1.2258 \times 10^{-2}$

**4.**




$$Y = \frac{W}{A}.\frac{\ell}{\Delta \ell}$$ so, $$\Delta \ell = \frac{W\ell}{AY}$$

$$\Delta \ell_1 = \Delta \ell_2$$

$$\frac{W_1\ell}{AY_1} = \frac{W_2\ell}{AY_2} \Rightarrow \frac{W_1}{W_2} = \frac{Y_1}{Y_2} = 2$$

**5.** $B = \frac{P}{-\frac{\Delta V}{V}}$ $\Rightarrow$ $\left|\frac{\Delta V}{V}\right| = \frac{P}{B}$

$$\frac{\Delta V}{V} = \frac{3\Delta R}{R} = \frac{P}{B} \Rightarrow \frac{\Delta R}{R} = \frac{P}{3B}$$

**6.**


$\ell$ $\ell/3$

wire (1) wire (2)

A 3A

$\frac{\ell}{3}$

$\ell$

$x = \frac{F}{k} = \frac{F}{yA/\ell} = \frac{F\ell}{yA}$

$\gamma = \frac{(F/A)}{(\Delta\ell/\ell)} = \frac{F\ell}{AD\ell}$ $\gamma = \frac{(F'/3A)}{(3\Delta\ell/\ell)} = \frac{F'\ell}{9A\Delta\ell}$

so F′ = 9F

**7.** Rate of heat produced = power loss against viscous force

$\frac{dQ}{dt} = f_v \times v = (6\pi\eta rv) \times v$

$\frac{dQ}{dt} = 6\pi\eta rv^2 \propto (r)(r^2)^2$

$\frac{dQ}{dt} \propto r^5$

**8.** Strain = $\frac{\square}{L}$, stress = $\frac{Mg}{A}$

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

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

= $\frac{1}{2} Mg\ell$

**9.** $V_T = \frac{2}{9}\frac{(\rho - \sigma)r^2}{\eta g}$

$\frac{V_1}{V_2} = \left(\frac{r_1}{r_2}\right)^2 \left(\frac{\rho_1 - \sigma}{\rho_2 - \sigma}\right)$

$\frac{V_1}{V_2} = \left(\frac{1}{2}\right)^2 \left(\frac{8\rho - .1\rho}{\rho - .1\rho}\right)$

$\frac{V_1}{V_2} = \frac{1}{4}\left(\frac{7.9}{.9}\right)$

$\frac{V_1}{V_2} = \frac{79}{36}$

## PART - II

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

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

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

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

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

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

$$= \frac{(7.8-1.2)}{(7.8-1)} \times \frac{10\times 8.5\times 10^{-4}}{13.2}$$

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

**3.** $f = \frac{v}{2\ell} = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}} = \frac{1}{2\ell}\sqrt{\frac{T}{Ad}}$

Also Y = $\frac{T\ell}{A\Delta\ell}$ $\Rightarrow$ $\frac{T}{A} = \frac{Y\Delta\ell}{\ell}$ $\Rightarrow$ $f = \frac{1}{2\ell}\sqrt{\frac{y\Delta\ell}{\ell d}}$

$\ell$ = 1.5m, $\frac{\Delta\ell}{\ell}$ = 0.01, d = $7.7 \times 10^3$ kg/$m^3$

y = $2.2 \times 10^{11}$ N/$m^2$

After solving

$$f = \sqrt{\frac{2}{7}} \times \frac{10^3}{3} Hz$$

f ≈ 178.2 Hz

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

P = YαΔθ = $2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100 = 2.2 \times 10^{8}$ Pa

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

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

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

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

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

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

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

**6.** $\Delta P = \frac{mg}{a}$

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

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

**7.** ΔL = LαΔT

strain = $\frac{\Delta L}{L}$ = αΔT

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

**8.** $\delta = \frac{\rho_0 Vg \times L}{Ay}$

$\delta' = \frac{(\rho_0 - \rho_L)vg \times L}{Ay}$

$\Rightarrow \frac{\delta'}{\delta} = \frac{\rho_0 - \rho_L}{\rho_0} = \frac{8-2}{8}$

$\delta' = 3$ mm