

Previous Years Questions	JEE Mains/Solutions
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1.(A) $\frac{E_1}{E_2} = \frac{A_1 T_1^4}{A_2 T_2^4} = \frac{R_1^2 T_1^4}{R_2^2 T_2^4} = \frac{1^2 \times 4000^4}{4^2 \times 2000^4} = \frac{16}{16} = 1$

2.(B) $Q = m \cdot c \Delta\theta$; if $\Delta\theta = 1K$, then $Q = mc$. thermal capacity

3.(C) When light incident on pin hole enters into the box and suffers successive reflections at the inner walls. At each reflection some energy is absorbed, hence the ray once it enters the box can never come out and pin hole acts like a perfect black body.

4.(A) According to Newton's law of cooling, the rate of cooling of a body is directly proportional to the temperature difference between the body and the surroundings.

5.(A) Factual information

6.(D) Elastic energy stored in the wire is

$$U = \frac{1}{2} \times \text{Stress} \times \text{Strain} \times \text{Volume} = \frac{1}{2} \times \frac{F}{A} \times \frac{\Delta l}{L} \times AL = \frac{1}{2} F \Delta l = \frac{1}{2} \times 200 \times 1 \times 10^{-3} = 0.1J$$

7.(D) As work done in stretching the wire = Potential energy stored

$$= \frac{1}{2} \times \text{Stress} \times \text{Strain} \times \text{Volume} = \frac{1}{2} \times \frac{F}{A} \times \frac{l}{L} \times AL = \frac{1}{2} Fl$$

8.(D) The two slabs are in series

$$\therefore k_{eq} = \frac{x + 4x}{\frac{x}{k} + \frac{4x}{2k}} = \frac{5k}{3} \Rightarrow \text{Heat flow rate} = \left(\frac{5k}{3} \right) \frac{A}{(5x)} (T_2 - T_1) \Rightarrow H = \left[\frac{kA}{x} (T_2 - T_1) \right] \times \frac{1}{3} \therefore$$

$$f = \frac{1}{3}$$

9.(D) From Stefan's law, the energy radiated by sun is given by $P = \sigma e AT^4$.

In 1st case, $P_1 = \sigma e \times 4\pi R^2 \times T^4$

In 2nd case, $P_2 = \sigma e \times 4\pi (2R)^2 \times (2T)^4$
 $= \sigma e \times 4\pi R^2 \times T^4 \times 64 = 64P_1$

The rate at which energy received at earth is : $E = \frac{P}{4\pi R_{SE}^2} \times A_E$

Where, A_E = area of earth and R_{SE} = distance between sun and earth

So, In 1st case,

$$E_1 = \frac{P_1}{4\pi R_{SE}^2} \times A_E, \quad E_2 = \frac{P_2}{4\pi R_{SE}^2} \times A_E = 64E_1. \text{ Hence, ratio is 64.}$$

10.(A) Consider a concentric spherical shell of radius r and thickness dr as shown in the figure. ($r_1 < r < r_2$)

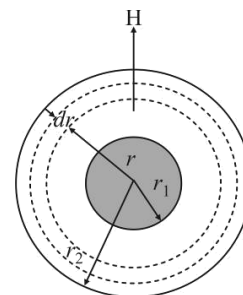
The radial rate of flow of heat through this shell in steady state will be

$$H = \frac{dQ}{dt} = -KA \frac{dT}{dr} = -K(4\pi r^2) \frac{dT}{dr}$$

$$\Rightarrow \int_{r_1}^{r_2} \frac{dr}{r^2} = -\frac{4\pi K}{H} \int_{T_1}^{T_2} dT$$

This on integration and simplification gives,

$$H = \frac{dQ}{dt} = \frac{4\pi K r_1 r_2 (T_1 - T_2)}{r_2 - r_1} \Rightarrow \frac{dQ}{dt} \propto \frac{r_1 r_2}{(r_2 - r_1)}$$

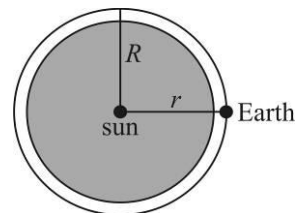


11.(D) Energy radiated by sun per unit time = $\sigma T^4 \times 4\pi R^2$

$\Rightarrow$ Energy received per unit time per unit area on earth

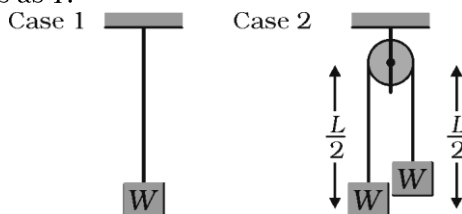
$$= \frac{\sigma T^4 \times 4\pi R^2}{4\pi r^2} = \frac{\sigma T^4 \times R^2}{r^2}$$

$$\Rightarrow \text{Power incident on earth} = \frac{\sigma T^4 R^2}{r^2} \times \pi r_0^2$$



[Here πr_0^2 is the projected area of earth that receives this power]

12.(A) Let us consider the length of wire as L and cross-sectional area A , the material of wire has Young's modulus as Y .



Then, for 1st case, $Y = \frac{w/A}{l/L}$

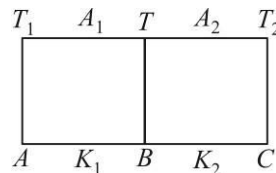
For 2nd case, $Y = \frac{w/A}{2l'/L} \Rightarrow l' = \frac{l}{2}$

So, total elongation of both sides = $2l' = l$

13.(C) Let the temperature at the interface be T .

For part AB, $\frac{Q_1}{t} \propto \frac{(T_1 - T)K_1}{l_1}$

For part BC, $\frac{Q_2}{t} \propto \frac{(T - T_2)K_2}{l_2}$



At equilibrium, $\frac{Q_1}{t} = \frac{Q_2}{t} \quad \therefore \quad \frac{(T_1 - T)K_1}{l_1} = \frac{(T - T_2)K_2}{l_2} \quad \Rightarrow \quad T = \frac{T_1 K_1 l_2 + T_2 K_2 l_1}{K_1 l_2 + K_2 l_1}$

14.(B) We have that $\frac{dQ}{dt} = KA \frac{d\theta}{dx}$

In steady state flow of heat,

$$d\theta = \frac{dQ}{dt} \times \frac{1}{KA} \times dx \quad \Rightarrow \quad \theta_H - \theta = k'x \quad \Rightarrow \quad \theta = \theta_H - k'x \quad (\text{where } k' \text{ is some constant})$$

The equation $\theta = \theta_H - K'x$ represents a straight line

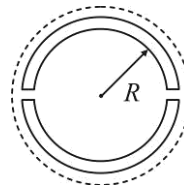
15.(D) $\Delta L = L\alpha \Delta T$

Now, $\frac{F}{S} = \frac{\Delta L}{L} Y$

$$F = \alpha \Delta T Y S$$

So, $F' = 2F$ (for equilibrium of each semi-circular part)

$$F = 2\alpha \Delta T Y S$$

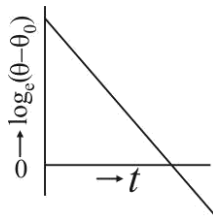


- 16.(A)** According to Newton's law of cooling

$$\frac{d\theta}{dt} = -k(\theta - \theta_0)$$

$$\int \frac{d\theta}{\theta - \theta_0} = -k \int dt$$

$$\ln(\theta - \theta_0) = -kt + C$$



So graph is straight line.

- 17.(B)** According to Newton's law of cooling, the rate of loss of heat is directly proportional to the difference of temperature of the body and surroundings.

$$\frac{dQ}{dt} = k(T_2 - T_1) \quad \dots (i)$$

and $dQ = msdT_2$

$$\therefore \frac{dQ}{dt} = \frac{msdT_2}{dt} \quad \dots (ii)$$

From Eqs. (i) and (ii), we get $-\frac{msdT_2}{dt} = k(T_2 - T_1)$

$$\Rightarrow \frac{dT_2}{T_2 - T_1} = -\frac{k}{ms} dt = -k dt \quad \left[\because K = \frac{k}{ms} \right]$$

On integrating, we get $\log_e(T_2 - T_1) = -Kt + C$ or $T_2 = T_1 + C'e^{-Kt}$

- 18.(D)** If a layer of thickness dr is evaporated, then

Change in surface energy

$$= \text{Change in surface area} \times T$$

$$= [4\pi(r + dr)^2 - 4\pi r^2]T$$

$$= [4\pi r^2 + 4\pi dr^2 + 8\pi r dr - 4\pi r^2]T$$

As dr is very small, so dr^2 neglected.

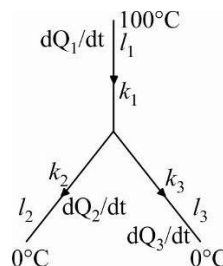
So, change in surface energy $= 8\pi r dr T$

Energy required to evaporate layer of thickness $dr = (4\pi r^2 dr)\rho L$

The processes of evaporation just starts, if change in surface energy is just sufficient to evaporate the water layer.

$$\therefore (4\pi r^2 dr)\rho L = (8\pi r dr)T \Rightarrow r = \frac{2T}{\rho L}$$

- 19.(A)** $\frac{dQ_1}{dt} = \frac{dQ_2}{dt} + \frac{dQ_3}{dt}$
- $$\Rightarrow \frac{0.92(100 - T)}{46} = \frac{0.26(T - 0)}{13} + \frac{0.12(T - 0)}{12}$$
- $$\Rightarrow T = 40^\circ\text{C}$$
- $$\frac{dQ_1}{dt} = \frac{0.92 \times (100 - 40) \times 4}{46} = 4.8 \text{ cal/sec}$$



20.(C) Thermal strain in the wire, $\frac{\Delta l}{l} = \alpha \Delta T$

Thermal stress in rod is the pressure due to the thermal strain

$$\text{Thermal stress} = Y \times \text{strain} = Y \left(\frac{\Delta l}{l} \right)$$



$$\text{Thermal stress} = \frac{F}{A} = \text{pressure} = Y \alpha \Delta T$$

$$\text{Given, } \Delta T = 100^\circ\text{C}, Y = 2 \times 10^{11} \text{ Nm}^{-2} \quad \alpha = 1.1 \times 10^{-5} \text{ K}^{-1}$$

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

21.(A) We know that time period, $T = 2\pi \sqrt{\frac{L}{g}}$

$$\text{When additional mass M is added to its bob } T_M = 2\pi \sqrt{\frac{L + \Delta L}{g}}$$

where, ΔL is increase in length.

$$\text{We know that } Y = \frac{Mg / A}{\Delta L / L} = \frac{MgL}{A\Delta L}$$

$$\Rightarrow \Delta L = \frac{MgL}{AY} \quad \Rightarrow \quad T_M = 2\pi \sqrt{\frac{L + \frac{MgL}{AY}}{g}} \quad \Rightarrow \quad \left(\frac{T_M}{T} \right)^2 = 1 + \frac{Mg}{AY}$$

$$\text{or } \frac{Mg}{AY} = \left(\frac{T_M}{T} \right)^2 - 1 \quad \text{or } \frac{1}{Y} = \frac{A}{Mg} \left[\left(\frac{T_M}{T} \right)^2 - 1 \right]$$

22.(D) Time period of a pendulum, $T = 2\pi \sqrt{\frac{l}{g}}$

where l is length of pendulum and g is acceleration due to gravity.

$$\text{Change in time period of a pendulum, } \frac{\Delta T}{T} = \frac{1}{2} \frac{\Delta l}{l}$$

$$\text{When clock gains 12 s, we get } \frac{12}{T} = \frac{1}{2} \alpha (40 - \theta)$$

$$\text{When clock loses 4 s, we get } \frac{4}{T} = \frac{1}{2} \alpha (\theta - 20)$$

$$\text{Comparing Eqs. (i) and (ii), we get } 3 = \frac{40 - \theta}{\theta - 20}$$

$$\Rightarrow 3\theta - 60 = 40 - \theta \Rightarrow 4\theta = 100 \Rightarrow \theta = 25^\circ\text{C}$$

$$\text{Substituting the value of } \theta \text{ in Eq. (i), we have } \frac{12}{T} = \frac{1}{2} \alpha (40 - 25) \Rightarrow \frac{12}{24 \times 3600} = \frac{1}{2} \alpha (15)$$

$$\alpha = \frac{24}{24 \times 3600 \times 15}, \quad \alpha = 1.85 \times 10^{-5} / ^\circ\text{C}$$

Thus, the coefficient of linear expansion in a pendulum clock $= 1.85 \times 10^{-5} / ^\circ\text{C}$

23.(D) $K = \frac{p}{(-\Delta V / V)} \Rightarrow \frac{\Delta V}{V} = \frac{p}{K} \Rightarrow -\Delta V = \frac{pV}{K}$

Change in volume, $\Delta V = \gamma v \Delta T$

where, γ = coefficient of volume expansion

Again, $\gamma = 3\alpha$

α is coefficient of linear expansion

$$\therefore \Delta V = V(3\alpha)\Delta T \quad \therefore \quad \frac{pV}{K} = V(3\alpha)\Delta T \quad \therefore \quad \Delta T = \frac{p}{3\alpha K}$$

24.(D) $\therefore \text{Stress} = \frac{\text{Weight}}{\text{Area}}$

Volume will become (9^3) times.

So weight = volume $\times$ density $\times g$ will also become $(9)^3$ times.

$$= \frac{9^3 \times W_0}{9^2 \times A_0} = 9 \left(\frac{W_0}{A_0} \right)$$

Hence, the stress increases by a factor of 9.

25.(C) $\therefore \text{Bulk modulus, } K = \frac{\text{Volumetric stress}}{\text{Volumetric strain}} = \frac{\Delta p}{\frac{\Delta V}{V}}$

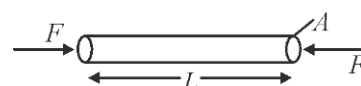
$$\Rightarrow K = \frac{mg}{\alpha \left(\frac{3\Delta r}{r} \right)} \left[\because V = \frac{4}{3} \pi r^3, \text{ so } \frac{\Delta V}{V} = \frac{3\Delta r}{r} \right] \Rightarrow \frac{\Delta r}{r} = \frac{mg}{3\alpha K}$$

26.(C) For No change in length, $\Delta L + (-\Delta \ell) = 0$

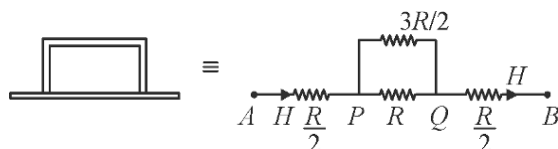
ΔL = increase in length due to change in temperature.

$-\Delta \ell$ = decrease in length due to compressive stress.

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



27.(A) $R = \frac{1}{k} \frac{L}{A}$

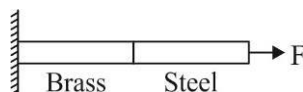


$$R_{eq} = \frac{3R/2 \times R}{3R/2 + R} + R = \frac{3R}{5} + R = \frac{8R}{5}$$

$$H = \frac{120}{(8R/5)} = \frac{75}{R}, \quad T_P = T_A - \frac{75}{R} \left(\frac{R}{2} \right)$$

$$T_Q = T_B + \frac{75}{R} \left(\frac{R}{2} \right), \quad T_P - T_Q = (T_A - T_B) - 75 = 120 - 75 = 45^\circ\text{C}$$

28.(None)
$$\Delta \ell = \frac{F}{Y_1 A} \frac{\ell}{\ell} + \frac{F}{Y_2 A} \frac{\ell}{\ell} = 0.2 \times 10^{-3}$$



$$\frac{F}{A} \left(\frac{\ell}{Y_1} + \frac{\ell}{Y_2} \right) = 0.2 \times 10^{-3}$$

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

$$\frac{F}{A} = 8 \times 10^{-6} \frac{N}{m^2}$$

No option Match

29.(A) Heat released by the unknown metal = heat absorbed by the calorimeter and water

$$\Rightarrow M_{\text{metal}} \times S_{\text{metal}} \times (100 - 21.5) = M_{\text{brass}} S_{\text{brass}} (21.5 - 8.4) + M_{\text{water}} S_{\text{water}} (21.5 - 8.4)$$

$$\Rightarrow 192 \times S_{\text{metal}} \times 78.5 = 128 \times 394 \times 13.1 + 240 \times 4200 \times 13.1$$

$$\Rightarrow S_{\text{metal}} = 919.95 \text{ J / kg / } ^\circ\text{C}$$

30.(D) $R = \frac{L}{kA} = \frac{1}{(0.1)A} = \frac{10}{A}$; $I = \frac{V}{R} = \frac{900}{\frac{10}{A}} = 90 \text{ A}$; $\frac{I}{A} = 90$

31.(C) $\alpha_A = \frac{\Delta L}{L(180^\circ\text{C} - 30^\circ\text{C})}$; $\alpha_B = \frac{\Delta L}{L(T^\circ\text{C} - 30^\circ\text{C})}$

$$\frac{\alpha_A}{\alpha_B} = \frac{T^\circ\text{C} - 30^\circ\text{C}}{150^\circ\text{C}} \Rightarrow 4 \times 150^\circ\text{C} = 37^\circ\text{C} - 90^\circ\text{C} \Rightarrow T = 230^\circ\text{C}.$$

32.(D) Boiling point and melting point of water in given scale are x_0 and $\frac{x_0}{3}$ respectively.

$$\Rightarrow \frac{\frac{x_0}{2} - \frac{x_0}{3}}{x_0 - \frac{x_0}{3}} = \frac{y - 0}{100 - 0}$$

where y is reading in $^\circ\text{C}$.

$$\frac{\frac{x_0}{6}}{\frac{2x_0}{3}} = \frac{y}{100} \text{ or } y = 25^\circ\text{C}.$$

33.(D) By the principle of calorimetry

$$100S_A(90 - 100) + 50S_B(90 - 75) = 0 \quad \dots(i)$$

$$\text{and } 100S_A(T - 100) + 50S_B(T - 50) = 0 \quad \dots(ii)$$

where S_A and S_B are specific heats of A and B respectively and T is final temperature in second case.

From (i)

$$4S_A = 3S_B$$

From (ii)

$$\frac{S_A}{S_B} = -\frac{50(T - 50)}{100(T - 100)} \text{ or } T = 80^\circ\text{C}.$$

34.(D) By principle of calorimetry

$$0.1 \times 400(T - 500) + 0.5 \times 4200(T - 30) + 800(T - 30) = 0 \quad \text{or} \quad T = 36.4^\circ\text{C}$$

$\therefore$ Percentage change in temperature of water $\approx 20\%$.

35.(A) $[y] = [V_x A^y F^z]$

$$\text{or} \quad [mL^{-1}T^{-2}] = [(LT^{-1})^x (LT^{-2})^y (mLT^{-2})^z] \quad \text{or} \quad (mL^{-1}T^{-2}) = [m^z L^{x+y+z} T^{-x-2y-2z}]$$

Comparing powers of m , L and T on both sides.

$$z = 1$$

$$x + y + z = -1$$

$$-x - 2y - 2z = -2 \Rightarrow x = -4$$

$$y = 2$$

$$z = 1 \therefore \text{Required dimensional formula is } V^{-4} A^2 F.$$

36.(A) Heat needed to bring 50 gm water from 40°C to 0°C

$$Q_1 = 50 \times 4.2 \times 40 = 8400 \text{ J}$$

Out of this some heat is provided by 20gm ice.

$$Q_2 = 20 \times 2.1 \times 20 = 840 \text{ J}$$

$$Q = Q_1 - Q_2 = 7560$$

If mass ' m ' of ice is melted, then $7560 = m \times 334 + m \times 2.1 \times 20$ gives $m \approx 20 \text{ gm}$.

So, $m(\text{total}) = 40 \text{ gm}$

37.(C) $F = Mg$

$$\rightarrow \text{stress } \sigma = \frac{F}{A} = \frac{Mg}{A}$$

$$\text{Since } \frac{\sigma}{\epsilon} = \gamma \rightarrow \epsilon = \frac{\sigma}{\gamma}$$

$$\text{IN first case, } \epsilon = \frac{\Delta l}{l} = \frac{4 \times 10^{-3}}{2} = 2 \times 10^{-3}$$

$$\rightarrow \gamma = \frac{Mg / A}{(2 \times 10^{-3})}$$

After dipping in liquid,

Consider equilibrium of block of mass M .

Where F is the force applied by steel wire and

B = Buoyant force $= \rho_l V g$

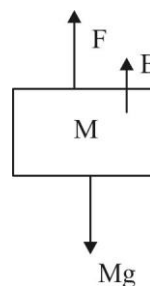
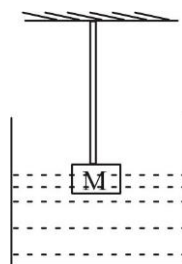
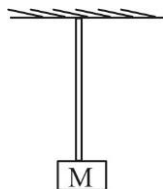
$$\text{Since } M = \rho V \text{ and } \frac{\rho_l}{\rho} = \frac{2}{8} = 0.25 \text{ (given)}$$

$$B = \frac{Mg}{4}$$

$$F = Mg - \frac{Mg}{4} = \frac{3Mg}{4}; \quad \epsilon = \frac{F / A}{Y} = \frac{3 \times \frac{Mg}{4A}}{Y} = \frac{3Mg}{4AY}$$

$$E = \frac{3Mg}{4A} \times \frac{2 \times 10^{-3}}{Mg / A} = 1.5 \times 10^{-3}; \quad \frac{\Delta l}{l} = 1.5 \times 10^{-3}$$

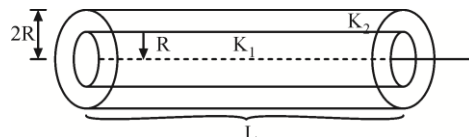
$$\Delta l = 2 \times 1.5 \times 10^{-3} m; \quad \Delta l = 3 \text{ mm}$$



38.(B) $R = \frac{L}{KA}; R_1 = \frac{l}{K_1 \pi R^2}, R_2 = \frac{l}{K_2 \pi (4R^2 - l^2)}$

$$\frac{1}{R_{eq}} = \frac{1}{R/1} + \frac{1}{R_2}$$

$$\frac{K_{eq} \times 4\pi R^2}{l} = \frac{K_1 \pi R^2}{l} + \frac{3K_2 \pi R^2}{l}, \quad K_{eq} = \frac{K_1 + 3K_2}{4}$$



39.(A) Let us assume x grams of water vaporizer.

$\Rightarrow$ amount of water frozen $= (150 - x)$

Heat gained by vaporized water = Heat lost by frozen water

$$\Rightarrow x \times L_V = (150 - x) \times L_f, \quad x \times 21 \times 10^5 = (150 - x) \times 3.36 \times 10^5$$

$$\Rightarrow 21x = 504 - 3.36x \quad \Rightarrow \quad x = \frac{504}{24.36} = 20.7g \approx 20g$$

40.(A) When catapult is released, elastic potential energy stored in cord gets converted to KE of stone.

EPE lost by cord = KE gained by stone

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

$$\Rightarrow Y \times \frac{\pi (3 \times 10^{-3})^2}{0.42} \times (0.2)^2 = 0.02 \times (20)^2 \quad \Rightarrow \quad Y = \frac{0.02 \times 400 \times 0.42}{\pi \times 9 \times 10^{-6} \times 0.04} \approx 3 \times 10^6 \text{ SI units}$$

41.(A) Stress $= \frac{\text{load}}{\text{area}} = \frac{mg}{\pi r^2}$

$$= \frac{4 \times 3.1\pi}{\pi \times (2 \times 10^{-3})^2}$$

$$= 3.1 \times 10^6 \text{ N/m}^2$$

42.(B) Mass_A = $V \times 8 \times 10^2$ mass_B = $V \times 10^3$

$$\therefore \text{mass}_B > \text{mass}_A$$

$$\left| \frac{ms d\theta}{dt} \right| = k \left| (\theta - \theta_0) \right| \quad \Rightarrow \quad \left| \frac{d\theta}{dt} \right| = \frac{k}{ms} |\theta - \theta_0|$$

$$m_A s_A = V \times 8 \times 10^2 \times 2000$$

$$m_B s_B = V \times 10^3 \times 4000$$

$$\therefore m_B s_B > m_A s_A \quad \therefore$$

slope of A will greater in magnitude at $t = 0$

43.(C) $P \xrightarrow{R:1} R(4,y,z) \quad (8,0,10)$
 $Q(2,-3,4)$

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

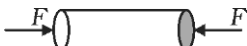
$$\frac{L_1}{A_1 Y_1} = \frac{L_2}{A_2 Y_2} \Rightarrow \frac{2}{R^2 \times 7} = \frac{1.5}{4 \times 4} \quad \Rightarrow \quad R = \sqrt{\frac{64}{21}} \approx 1.7 \text{ mm}$$

44.(B) $Q_2 \left[\frac{d}{3k} \mid \frac{Q}{k} \right] Q_1$

$$d \frac{dQ}{dt} = \frac{3KA(\theta_2 - \theta)}{d} = \frac{KA(\theta - \theta_1)}{3d}$$

$$\theta = \frac{\theta_1}{10} + \frac{9\theta_2}{10}$$

45.(D) Breaking stress $= \frac{F}{A} = \frac{F \times 4}{\pi d^2} \Rightarrow \frac{400 \times 4}{\pi \times d^2} = 379 \times 10^6 \Rightarrow d = 1.16 \times 10^{-3} = 1.16 \text{ mm}$

46.(A) 

$$\text{Strain} = \frac{\Delta L}{L} = \frac{\alpha L \Delta \theta}{L}$$

$$Y = \frac{F}{A \alpha \Delta \theta} \Rightarrow \alpha = \frac{F}{Y \pi r^2 T}$$

$$\left(Y = \frac{3F}{Y \pi r^2 T} \right)$$

47.(D) $Q_{\text{gain}} = Q_{\text{lost}}$

$$M_1 \times 0.5 \times 10 + M_1 L = M_2 \times 1 \times 50$$

$$L = \frac{M_2}{M_1} \times 50 - 5$$

48.(A) $y = \frac{\text{stress}}{\text{strain}} = \frac{F / A}{\Delta l / \ell}$

$$y = \frac{mg}{A \alpha \Delta T}, \quad m = \frac{y A \alpha \Delta T}{g} = 2\pi$$