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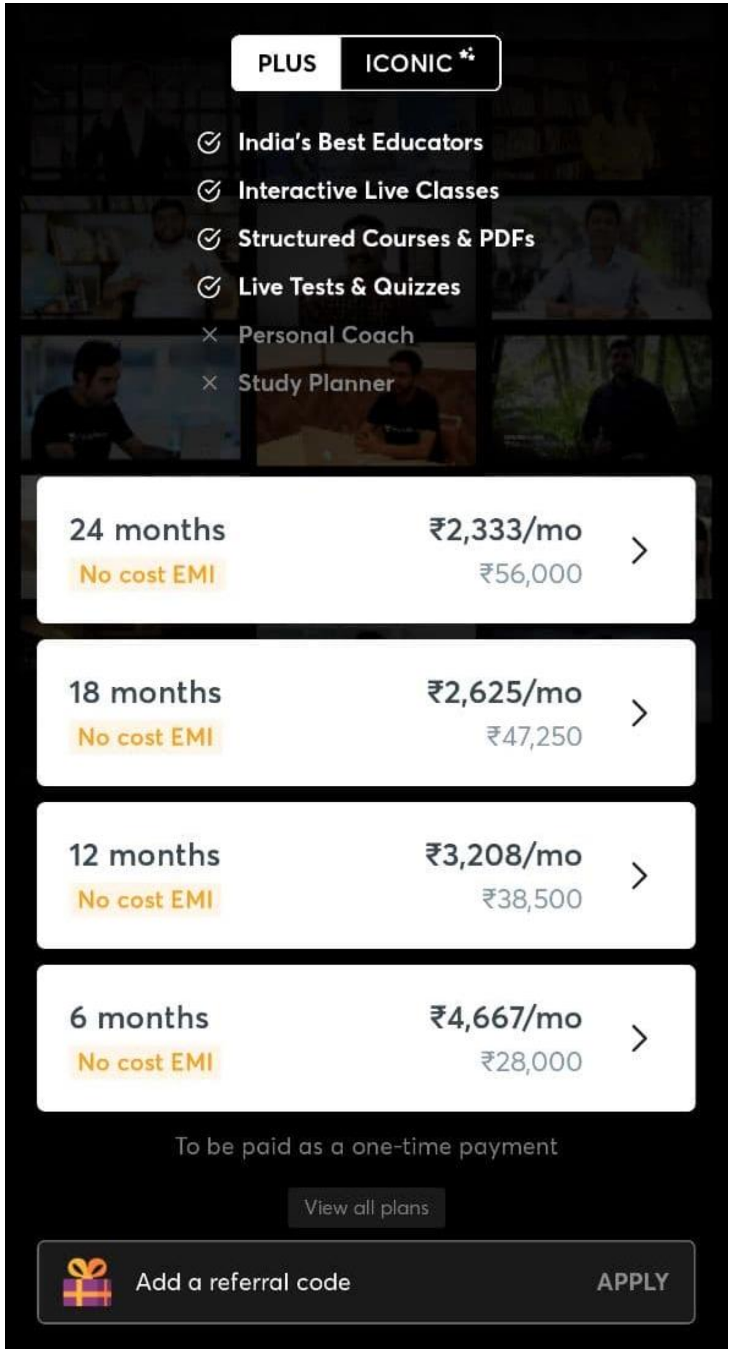
- Research work with HC Verma sir at IIT Kanpur
- Interviewed by International media.



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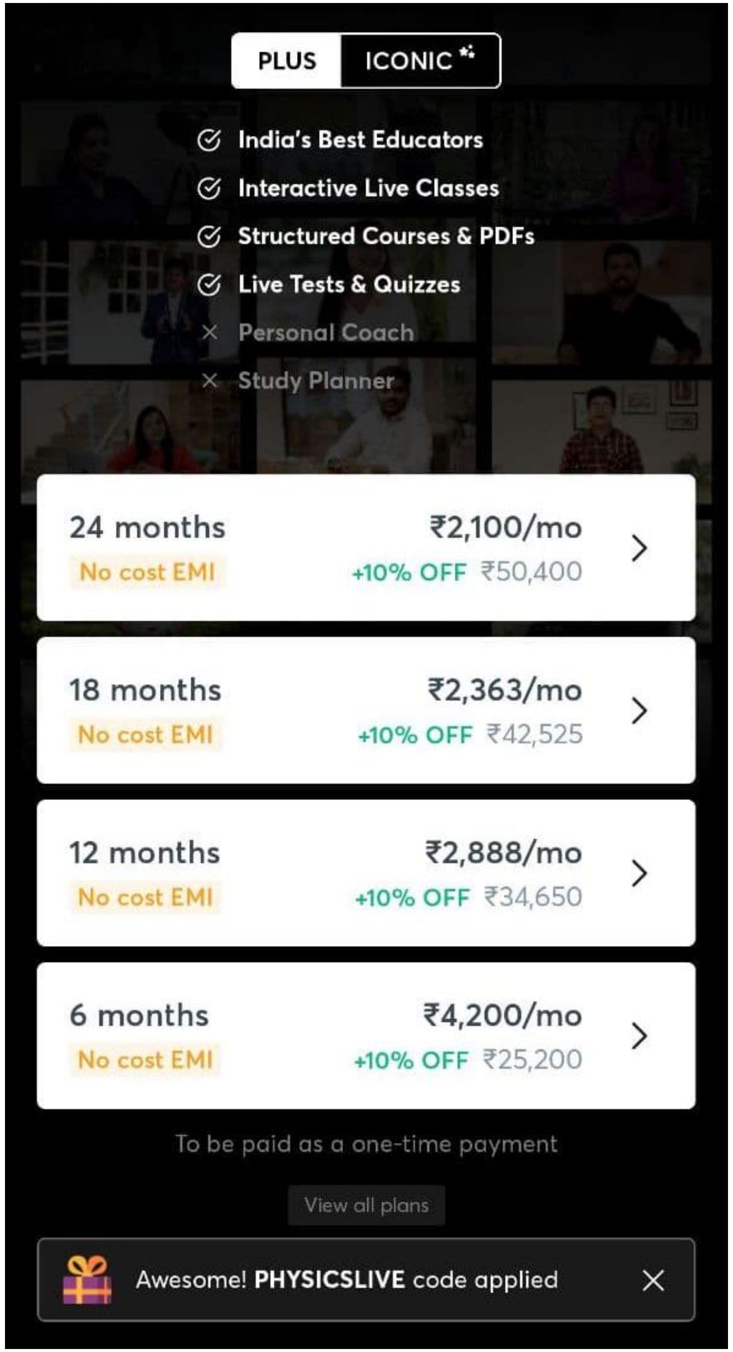

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Solution

Exercise: 1 (L-1)

Thermo-1 (Elasticity, Calorimetry, Thermal Expansion, Heat Transfer)

By Physicsaholics Team

1)

$$I = \sum m_1 r_1^2$$

$$I + \Delta I = \sum m_1 r_1^2 (1 + \alpha \Delta T)^2 = (1 + \alpha \Delta T)^2 \sum m_1 r_1^2$$

$$\simeq (1 + 2\alpha \Delta T) I$$

$$\Rightarrow \quad \Delta I = 2 I \alpha \Delta T$$

$$\Rightarrow \quad \frac{\Delta I}{I} = 2 \alpha \Delta T$$

Ans (d)

2)

Modulus of rigidity of steel is very high due to which change in its shape will be negligible

Modulus of rigidity of rubber is small & it's poisson's ratio is high due to which it's shape of bottom edge tapered to a tip at centre

Ans(d)

3)

$$\lambda_m = \frac{b}{T} = \frac{288 \times 10^6 \ nm - K}{2880 \ K}$$

$$= 1000 \ nm$$

$\Rightarrow$ U_2 is greatest

ANs(d)

4)

$$Y = \frac{F/A}{\Delta l/l} \Rightarrow \frac{\Delta l}{l} = \frac{F}{AY} = \frac{100}{\pi(10^{-3})^2 \times 2\times10^{11}}$$

$$\sigma = -\frac{(\Delta r/r)}{(\Delta l/l)} \Rightarrow \Delta r = -\frac{\sigma r \Delta l}{l}$$

$$\Rightarrow \Delta r = -\frac{\pi}{10} \times 10^{-3} \times \frac{100}{\pi \times 10^{-6} \times 2\times10^{11}} \text{ meter}$$

$$= -\frac{10}{2\times10^{5}} \text{ mm} = -.00005 \text{ mm}$$

$$\Rightarrow \text{final radius} = r + \Delta r = (1 - .00005) \text{ mm}$$

$$= .99995 \text{ mm}$$

Ans (d)

5) Let initial mass of water was 100g in which m gram converts into ice

$$(100-m)\times 21\times 10^5 = m\times 3.36\times 10^5$$

$$100-m = \dots$$

$$m = \frac{100}{1.16} = 86.2 \text{ gram}$$

Ans(a)

5) Let initial mass of water was 100g in which m gram converts into ice.

$(100-m)\times 21\times 10^5 = m\times 3.36\times 10^5$

$100-m = .16m$

$m = \frac{100}{1.16} = 86.2$ gram

Ans(a)

6) 200 g water at 70 C + 50 g ice at 0 C + flask of Heat Capacity c & T=70c

= final temperature 40 c

$$200\times1(70-40) + c(70-40) = 50L + 50\times1(40-0)$$

$$\Rightarrow \quad 6000 + 30c = 50L + 2000$$

$$5L - 3c = 400 \quad ---(1)$$

(250 g water + flask) at 40 C + 80 g ice at 0 C = final temperature is 10°C

$$\Rightarrow \quad 250\times1(40-10) + c(40-10) = 80L + 80\times1(10-0)$$

$$7500 + 30c = 80L + 800$$

$$8L - 3c = 670 \quad ---(11)$$

$$\Rightarrow \quad 3L = 270 \Rightarrow L = 90\ Cal/g = 3.78\times10^5\ J/kg$$

$$\simeq 3.8\times10^5\ J/kg$$

ANS(a)

7)

$$\Delta h = h \alpha \Delta T$$

$$= 93 \times 17 \times 10^{-6} \times (45^\circ - 25^\circ)$$

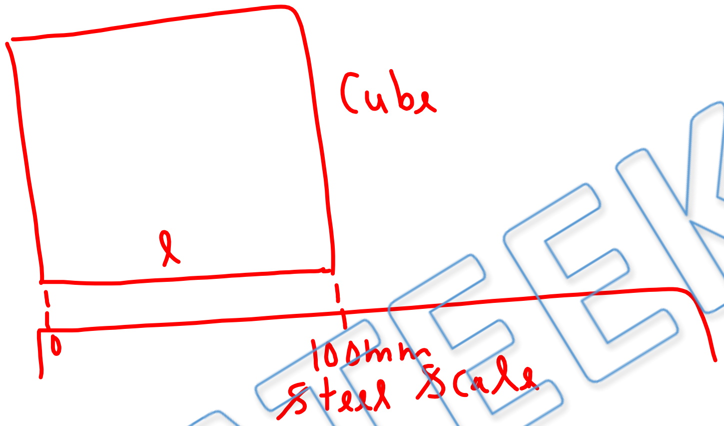
$$= 31620 \times 10^{-6} \text{ m}$$

$$= 31620 \text{ mm}$$

$= \text{order of } 10\text{mm}$

Ans (c)

8) at 40 C



actual side of cube at 40 C

l = actual distance b/w 0 mm & 100mm mark

$= 100(1+\alpha_s \times 40)$

side of cube at 0 C

$= 100(1+40\alpha_s)(1-40\alpha_x)$

$= 100[1+40(\alpha_s-\alpha_x)]$

> 100 mm Since $\alpha_s > \alpha_x$

Ans(a)

9)

$$F_b = F_{b_0}\left[1 + \underbrace{(\gamma_s - \gamma_l)}_{-ve}\Delta T\right]$$

$\Rightarrow$ F_b decreases on increasing temperature

now $W = mg - F_b$

$\Rightarrow$ W increases on increasing temperature.

Ans(c)

10)

temperature loss $= 3^\circ F = \frac{100}{180} \times 3^\circ C = \frac{5}{3}{}^\circ C$

Heat loosed by child $= 30000 \times 1 \times \frac{5}{3} = 50000$ Cal

Let m gram water evaporates

$m \times 580 = 50000$

$m = \frac{5000\cancel{0}}{58\cancel{0}}$

Rate of evaporation $= \frac{m}{\Delta t} = \frac{500\cancel{0}}{58 \times 2\cancel{0}} = 4.31\, g/min$

Ans(a)

11)

Volume of Hg at T°C $= V_0[1+\gamma_m T]$

" " bulb " " $= V_0[1+3\alpha_g T]$

excess volume of Hg $= V_0 T[\gamma_m - 3\alpha_g]$

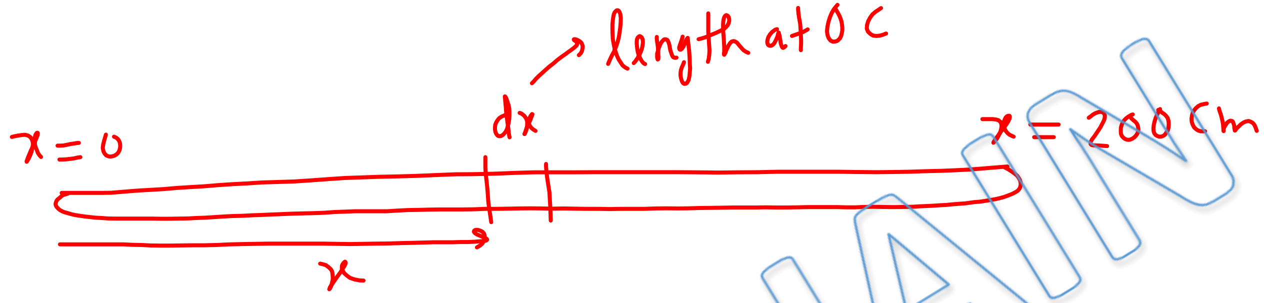
Cross sectional Area at T°C $= A_0[1+2\alpha_g T]$

height of Hg Column at T°C

$$= \frac{V_0 T[\gamma_m - 3\alpha_g]}{A_0[1+2\alpha_g T]}$$

ANS(b)

12)



Let change in length of dx is dl

$$dl = dx\,\alpha\,\Delta T = (3x+2)\times 10^{-6}\times 20\,dx$$

$$\Rightarrow \Delta l = 2\times 10^{-5}\int_0^{200}(3x+2)\,dx$$

$$= 2\times 10^{-5}\left[\frac{3x^2}{2}+2x\right]_0^{200} = 2\times 10^{-5}\left[\frac{3}{2}\times 4\times 10^{4}+400\right]$$

$$= 1.2 + .008 = 1.20 \text{ cm} = .0120 \text{ m}$$

$\Rightarrow$ final length $= 20120$ m

ANS(C)

13) Pressures at bottom of each Column must be equal

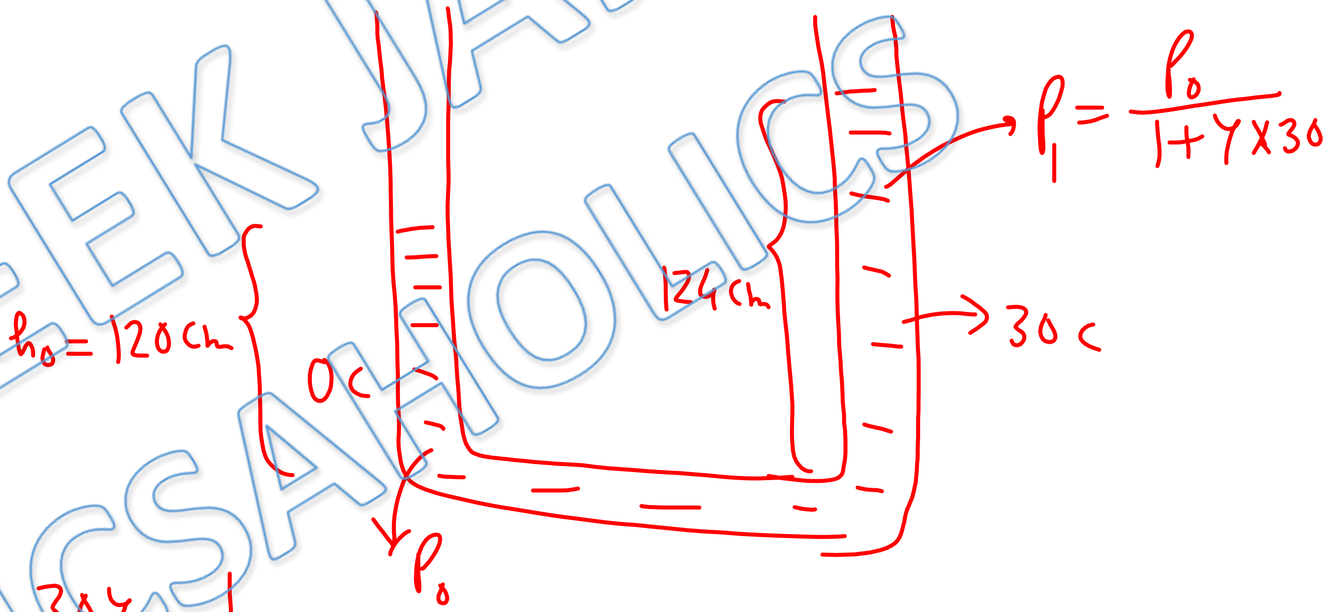
$$\rho_0 g h_0 = \rho_1 g h_1$$

$$\Rightarrow \rho_0 \times 120 = \frac{\rho_0}{1+\gamma\times 30} \times 124$$

$$\Rightarrow 1+30\gamma = \frac{124}{120}$$

$$\Rightarrow 1+30\gamma = \frac{31}{30} \Rightarrow 30\gamma = \frac{1}{30}$$

$$\Rightarrow \gamma = \frac{1}{900} = 11\times10^{-4}/^{\circ}C$$



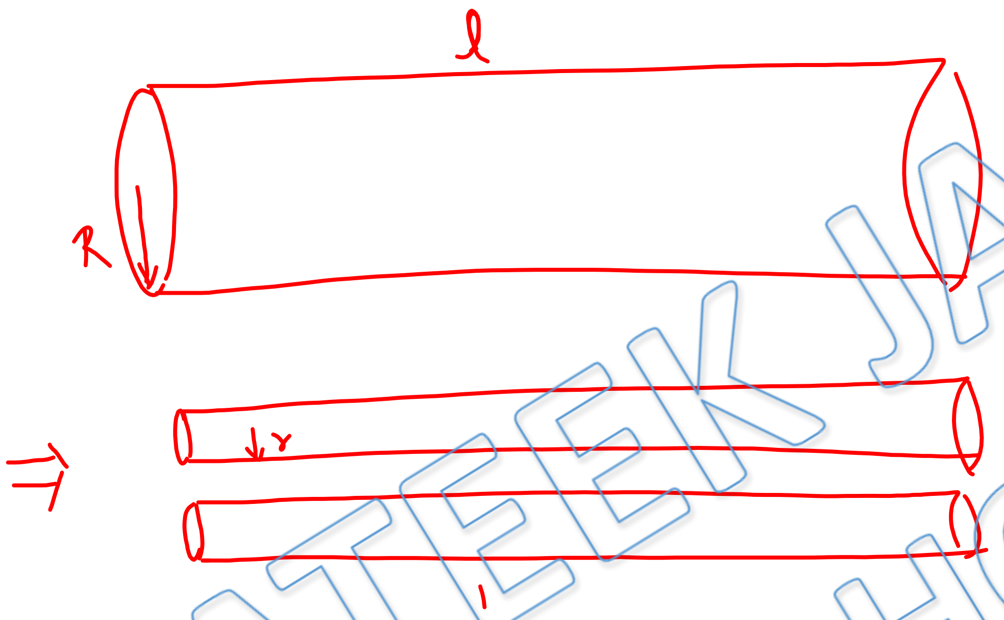
ANS(c)

14)

Liquid evaporates at all possible temperatures

Ans (b)

15)



$\pi R^2 l = \pi r^2 l \times n$

$r = \frac{R}{\sqrt{n}}$

n Identical cylinders

Radient power $\propto$ Surface Area

Initial surface Area $= 2\pi R l$

final ,, ,, $= 2\pi r l n$

$\Rightarrow \frac{\text{final power}}{\text{Initial ,,}} = \frac{\text{final Area}}{\text{Initial ,,}} = \frac{2\pi r l n}{2\pi R l} = \sqrt{n} = 2 \Rightarrow n = 4$

ANS(b)

16)

$$\frac{\Delta\theta}{\Delta t} = \frac{KA\Delta T}{l} \propto \frac{A}{l} \propto \frac{r^2}{l}$$

for first Rod $\quad \frac{r^2}{l} = \frac{4\,cm^2}{.5\,m} = 8\,\frac{cm^2}{m}$

for Second Rod $\quad \frac{r^2}{l} = \frac{4\,cm^2}{2\,m} = 2\,\frac{cm^2}{m}$

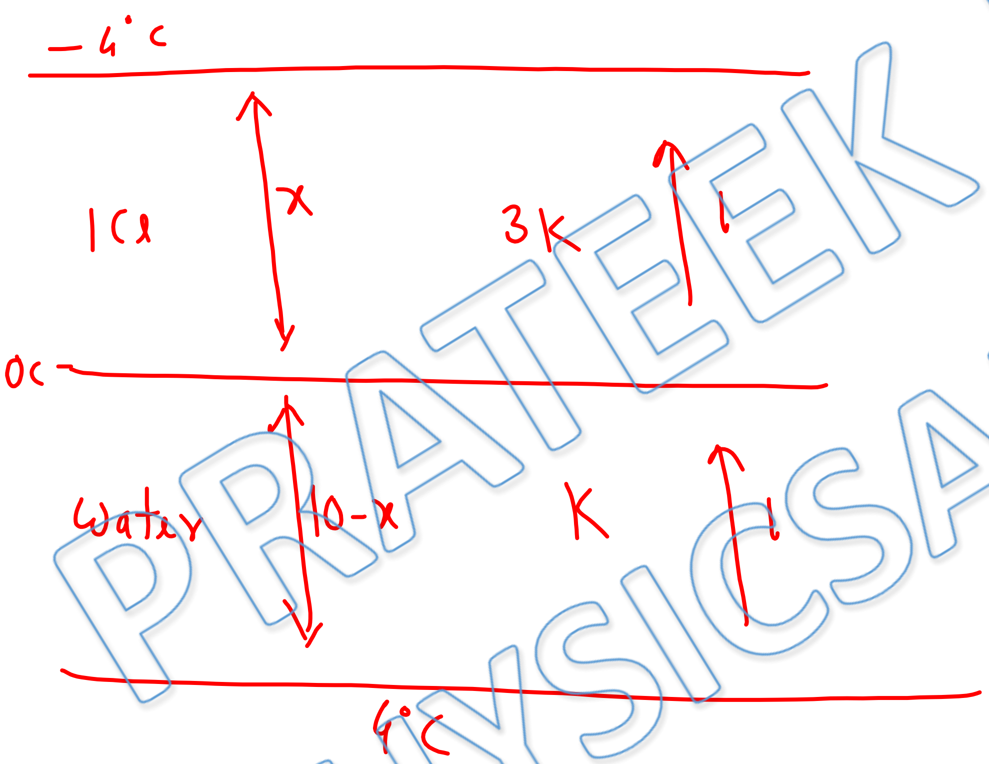
for third Rod $\quad \frac{r^2}{l} = \frac{.25\,cm^2}{.5\,m} = \frac{.5\,cm^2}{m}$

for fourth Rod $\quad \frac{r^2}{l} = \frac{1\,cm^2}{1\,m}$

Ans (a)

(A) will conduct maximum heat

(17)



$$l = \frac{KA \times 4}{10-x} = \frac{3KA \times 4}{x}$$

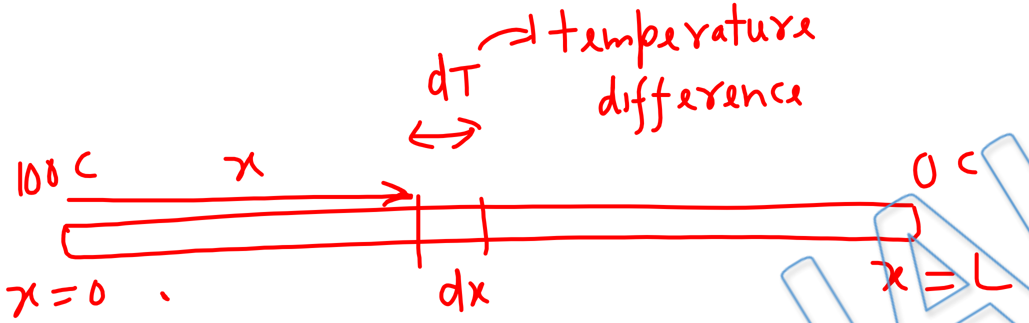
$$x = 30 - 3x$$

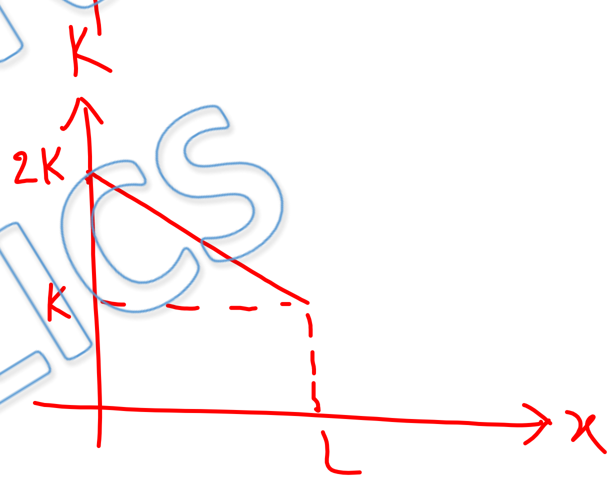
$$\Rightarrow 4x = 30$$

$$\Rightarrow x = 7.5\ m$$

Ans (a)

18)



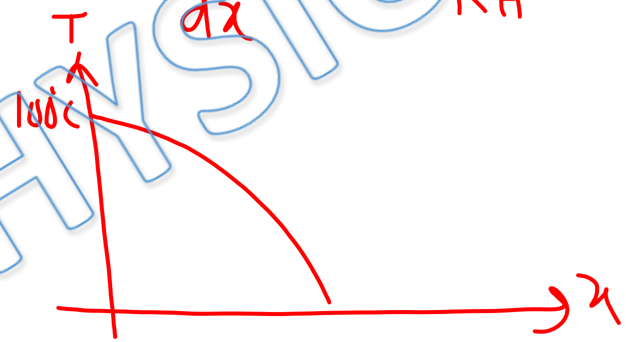


at $x = x$, $K' = 2K - \frac{Kx}{L}$

If Current (thermal) in rod is i

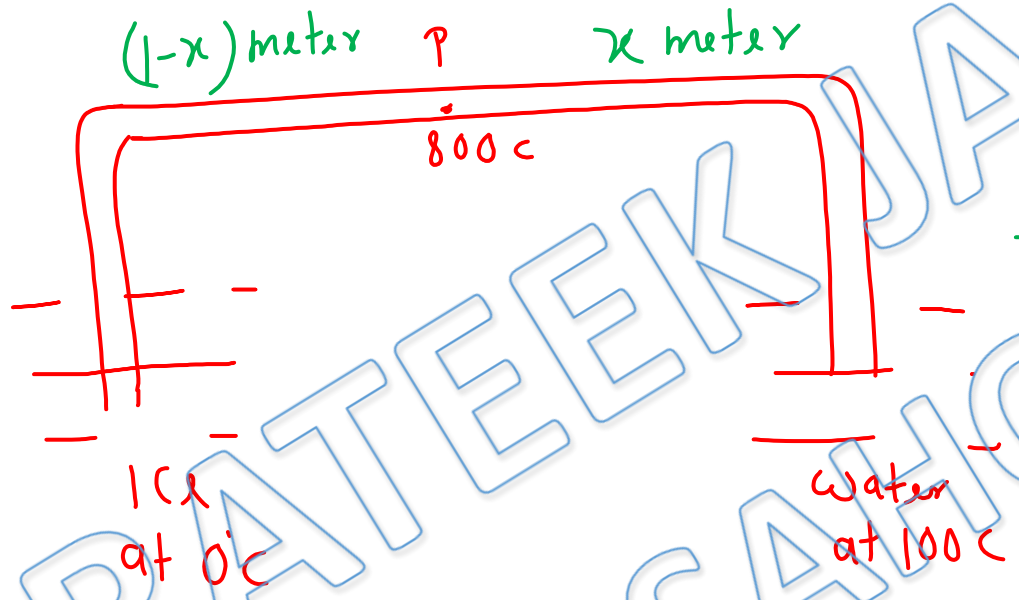
$\Rightarrow i = -\frac{KA\,dT}{dx}$

$\Rightarrow \frac{dT}{dx} = -\frac{i}{KA} \Rightarrow \left|\frac{dT}{dx}\right| = \frac{i}{KA}$ → increasing with x



Ans (b)

19)



$$L_v = 7L_f$$

$$\frac{\Delta Q_v}{\Delta t} = 7\frac{\Delta Q_f}{\Delta t}$$

$$\frac{KA(800-100)}{x} = \frac{7KA(800-0)}{1-x}$$

$$\Rightarrow 1 - x = 8x$$

$$\Rightarrow x = 1/9 \text{ meter}$$

$$\Rightarrow$$

Ans (c)

20)

Area under Curve $= \int y\,dx$

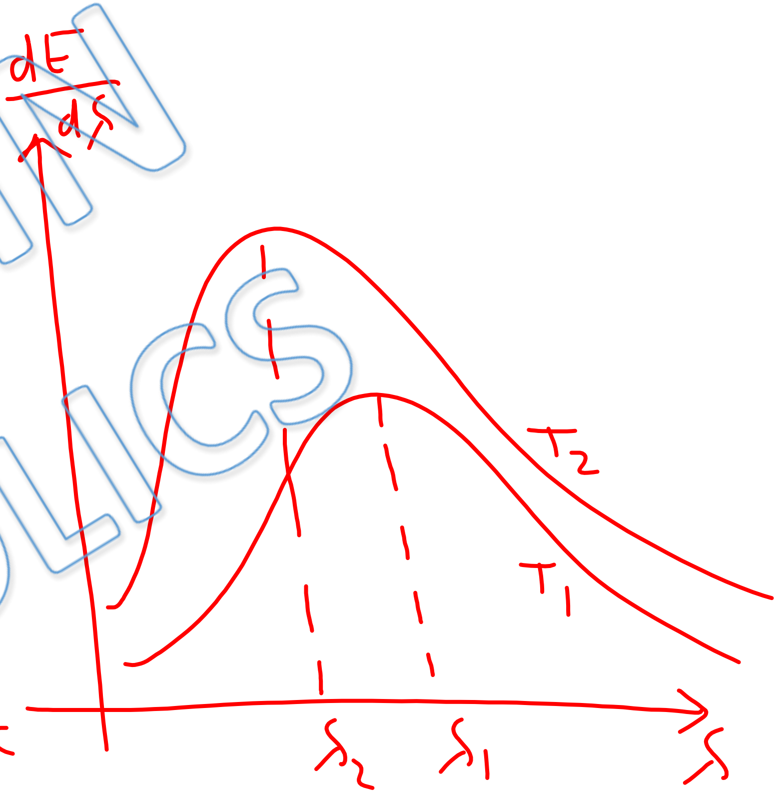
$= \int \frac{dE}{d\lambda} d\lambda = \Delta E \propto T^4$

$\Rightarrow$ Area $\propto T^4$

$\Rightarrow \frac{A_1}{A_2} = \left(\frac{T_1}{T_2}\right)^4 = \left(\frac{\lambda_2}{\lambda_1}\right)^4$, Since $\lambda_m b = c$

$\Rightarrow \left(\frac{\lambda_2}{\lambda_1}\right)^4 = \frac{1}{9}$

$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{3}$



Ans (d)

21)

$$\frac{dQ}{dt} \propto A \xrightarrow{} \text{surface Area}$$

$$\Rightarrow \quad ms\frac{dT}{dt} \propto A$$

$$\Rightarrow \quad \frac{dT}{dt} \propto \frac{A}{m}$$

for sphere $\dfrac{dT}{dt} \propto \dfrac{4\pi R^2}{\frac{4}{3}\pi R^3 \times \rho} \propto \dfrac{1}{R}$ $\Rightarrow$ smaller gulab jamun will get heated first

for Pizza $\dfrac{dT}{dt} \propto \dfrac{\pi R^2}{\rho\, \pi R^2 h}$ $\Rightarrow$ both Pizza will get heated togather

ANS(b)

22)

Power loss by black body due to radiation

$$-\frac{dQ}{dt} = \sigma A T^4$$

$$\Rightarrow -ms\frac{dT}{dt} = \sigma A T^4$$

$$\Rightarrow -\int_{T_1}^{T_2} T^{-4}\, dT = \frac{\sigma A}{ms}\int_0^t dt$$

$$\Rightarrow -\left[\frac{T^{-3}}{-3}\right]_{T_1}^{T_2} = \frac{\sigma A t}{ms} \Rightarrow t \propto \frac{1}{T_2^3} - \frac{1}{T_1^3}$$

ANS (c)

23)

To apply law of Calorimetry, time taken to achieve Equilibrium is not required

ANS(d)

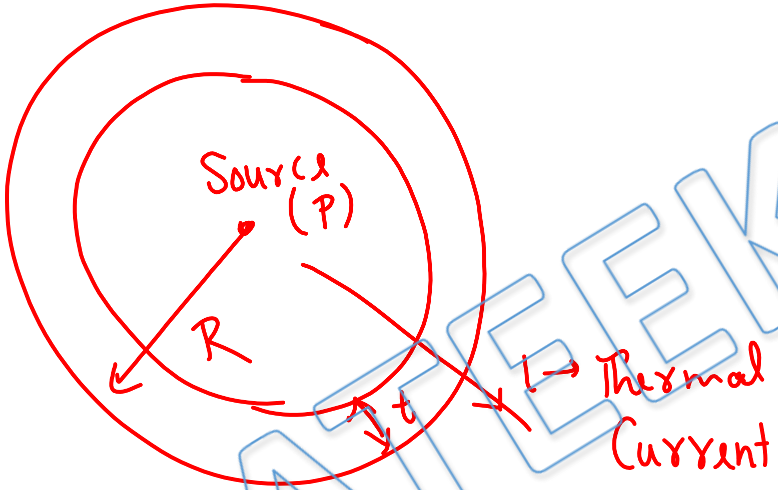
24)

Rate of melting of ice

$$\propto \frac{\Delta Q}{\Delta t} = \frac{KA\Delta T}{l}$$

(D) is right option

25)



$$\frac{dQ}{dt} = P = \frac{K4\pi R^2 T}{t}$$

$$\Rightarrow t = \frac{4\pi R^2 KT}{P}$$

Ans (a)

26)

$$\lambda_m T = b = 2.88 \times 10^6 \text{ nm-K}$$

$$T = 2880\,K = 2.88 \times 10^3\,K$$

$$\lambda_m = \frac{b}{T} = \frac{\cancel{2.88} \times 10^{\cancel{6}\,3}}{\cancel{2.88 \times 10^3}} = 10^3 \text{ nm}$$

$$\lambda_m = 1000 \text{ nm}$$

for black body radiates maximum energy at $\lambda_m = 1000\,nm$

so; it will radiate heigh energy at wavelength near to 1000 nm.

As given; $U_1 \rightarrow (499 - 500\,nm)$ & $U_2 \rightarrow (999 - 1000\,nm)$

so; $U_2 > U_1$

Ans: (D)

Chalo Niklo