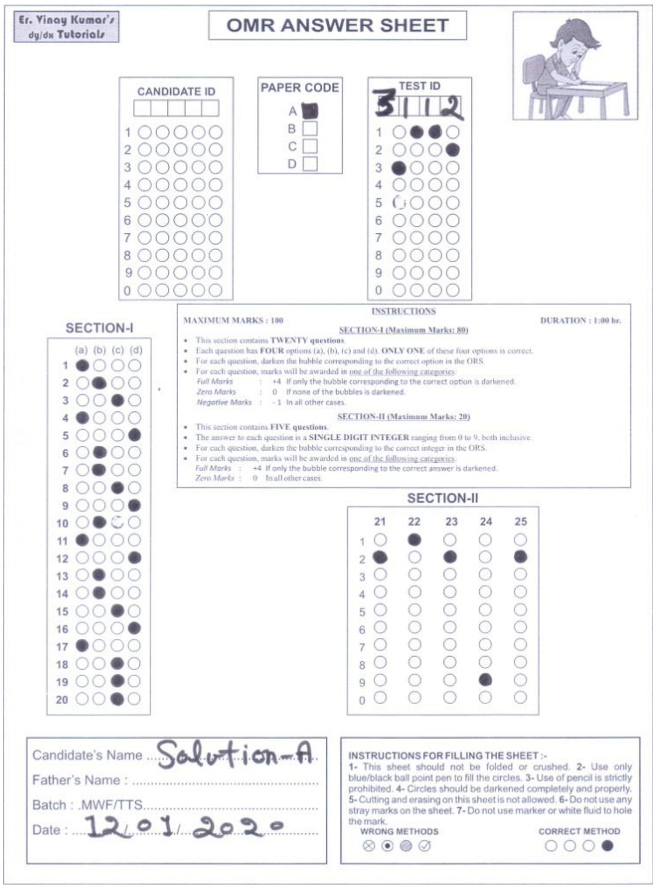
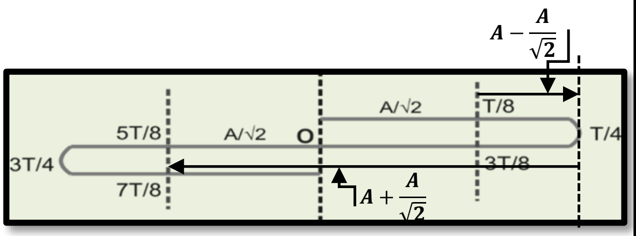
SET-A



Q1.



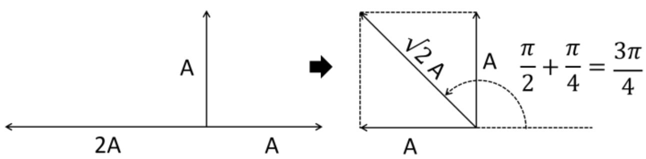
$$\text{Distance is} = \left(A-\frac{A}{\sqrt{2}}\right)+A+\frac{A}{\sqrt{2}}=2A$$

Q2. $x = A[\cos\omega t + 1]$

$\Rightarrow x = A + A\cos\omega t \Rightarrow$ This is a +ve cos curve ($x = A\cos\omega t$) imposed on line $x = A$

Q3.

$x = A\sin\omega t + A\sin(\omega t + \pi/2) + 2A\sin(\omega t + \pi)$



Equation of resultant SHM is $x = \sqrt{2}A\sin(\omega t + 3\pi/4)$

Q4. Phase diff. $\pi/2$ and motion directions perpendicular to each other give orbital motion. Since amplitudes are different, therefore the orbit is elliptical.

Q5.

$$A = \frac{1}{\sqrt{[a\omega^2 - 2b\omega + c]}}$$

At resonance A should be maximum.

For A to be maximum $[a\omega^2 - 2b\omega + c]$ should be minimum ⇨

$$D = a\omega^2 - 2b\omega + c ⇨ \frac{dD}{d\omega} = 2a\omega - 2b \quad (=0)$$

$$⇨ 2a\omega - 2b = 0 ⇨ \boldsymbol{\omega = \frac{b}{a}} ⇦ \text{Resonance frequency}$$

$$A = \frac{1}{\sqrt{[a\omega^2 - 2b\omega + c]}}$$

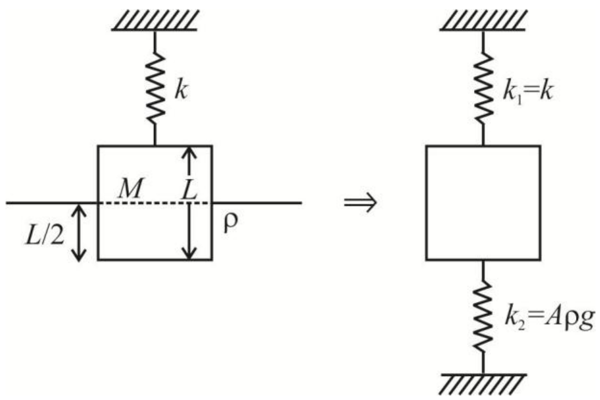
$$A \text{ becomes maximum at } \omega = \frac{b}{a}$$

$$⇨ A_{max} = \frac{1}{\sqrt{a\left(\frac{b}{a}\right)^2 - 2b\left(\frac{b}{a}\right) + c}} = \frac{1}{\sqrt{a\times\frac{b^2}{a^2} - \frac{2b^2}{a} + c}}$$

$$= \frac{1}{\sqrt{\frac{b^2}{a} - \frac{2b^2}{a} + c}} ⇨ A_{max} = \frac{1}{\sqrt{c - \frac{b^2}{a}}} ⇨ A_{max} = \frac{1}{\sqrt{\frac{ac - b^2}{a}}}$$

$$⇨ \boldsymbol{A_{max} = \sqrt{\frac{a}{ac - b^2}}}$$

Q6.

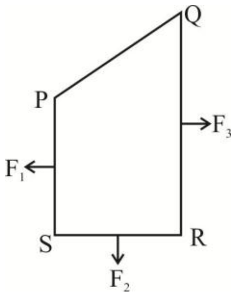


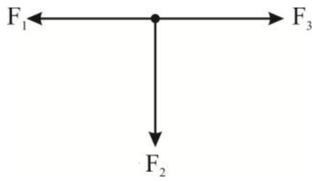
$$k_{eff} = k + A\rho g$$

$$\omega = \sqrt{\frac{k_{eff}}{M}} = \sqrt{\frac{k + A\rho g}{M}}$$

$$2\pi f = \left(\frac{k + A\rho g}{M}\right)^{1/2} \Rightarrow f = \frac{1}{2\pi}\left(\frac{k + A\rho g}{M}\right)^{1/2}$$

Q7. **(b)** As the net force on closed loop is equal to zero. So, force on *QP* will be equal and opposite to sum of forces on other 3 sides.





$\Rightarrow \sqrt{(F_3 - F_1)^2 + F_2^2}$

therefore $F_{QP} = \sqrt{(F_3 - F_1)^2 + F_2^2}$

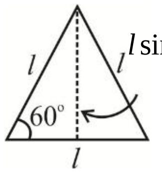
Q8. **(c)** Torque acting on equilateral triangle in a magnetic field B is

$\tau = MB_o \sin\theta$

$\Rightarrow \tau = i\ AB\sin\theta$ [iA=**M**]

Area of triangle

$A = \frac{1}{2} \times l \times \frac{l\sqrt{3}}{2}$



$l \sin 60^o = \frac{l\sqrt{3}}{2}$

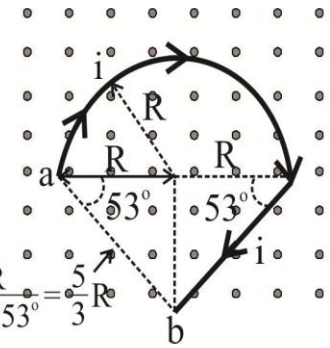
$\Rightarrow \quad A = \frac{\sqrt{3}}{4} l^2$ and $\theta = 90^o$

Substituting the given values in the expression for torque, we have

$\tau = i \times \frac{\sqrt{3}}{4} l^2 B \sin 90^o = \frac{\sqrt{3}}{4} i l^2 B \qquad (\because \sin 90^o = 1)$

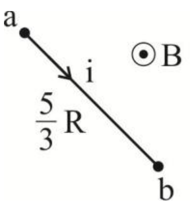
Hence, $\quad l = 2\left(\frac{\tau}{\sqrt{3}Bi}\right)^{1/2}$

Q9.



$\frac{R}{\cos 53^o} = \frac{5}{3}R$

$\Rightarrow$

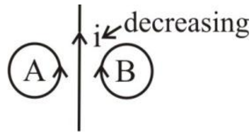


$\frac{5}{3}R$

$\odot$ B $\quad F = i\ (ab)\ B$

$\quad = i\frac{5}{3}RB$

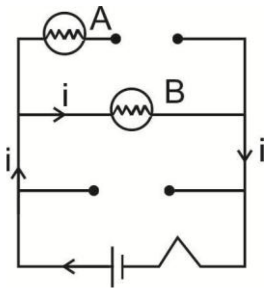
Q10. Since *i* is decreasing hence current in both the coils should in such direction so that they could support the current i



Q11. $Lxy = L + 4L - 2\sqrt{L \cdot 4L} = 5L - 4L = L$

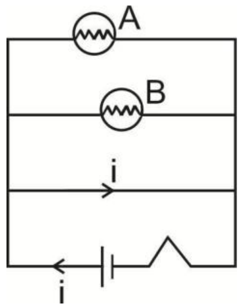
$$L_{eff} = \frac{5L \times L}{5L + L} = \frac{5}{6}L = 0.83L$$

Q12. Just at the moment the switch is connected inductance coils creat insulation then the effective circuit at the moment is⇨



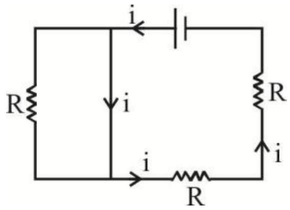
All the current passes through B and B immediately glows.

In steady state the coils act like zero resistance ⇒



The whole circuit is short circuited and both the bulbs die out.

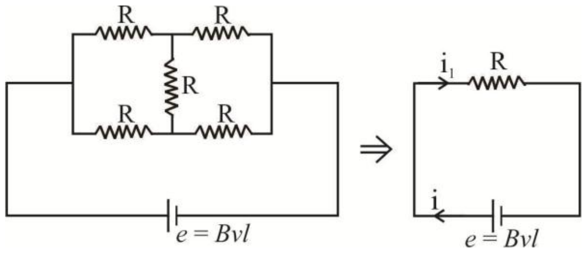
Q13. Effective circuit for calculating time constant is



R_{eff} = R+R=2R

$\tau = \frac{L}{R_{eff}} = \frac{L}{2R}$

Q14. Effective circuit is



$$i = \frac{Bvl}{R}$$

$$P = i^2R = \left(\frac{Bvl}{R}\right)^2 R = \frac{B^2v^2l^2}{R}$$

Q17. $KE = \dfrac{q^2B_0^2r^2}{2m}$

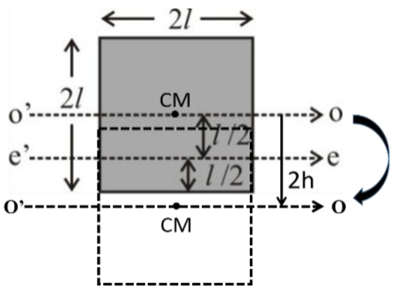
KE, B_0 are same,

$$\Rightarrow \text{constant} \propto \frac{q^2\ r^2}{m} \ \Rightarrow\ q^2 \propto \frac{m}{r^2}$$

$$\Rightarrow\ q \propto \frac{\sqrt{m}}{r}\ \Rightarrow\ \frac{q_1}{q_2} = \sqrt{\frac{m_1}{m_2}} \times \frac{r_2}{r_1}$$

$$\Rightarrow\ \frac{q_1}{q_2} = \sqrt{\frac{m}{4m}} \times \frac{2}{1} = 1\ \Rightarrow\ q_1 = q_2$$

Q18.



$$mgh = \frac{1}{2}I\omega^2 \Rightarrow \quad mg \cdot 2\left(\frac{l}{2}\right) = \frac{1}{2}I_e\omega^2$$

$$\Rightarrow \quad mgl = \frac{1}{2}\left[\frac{m\,(2l)^2}{12} + m\left(\frac{l}{2}\right)^2\right]\omega$$

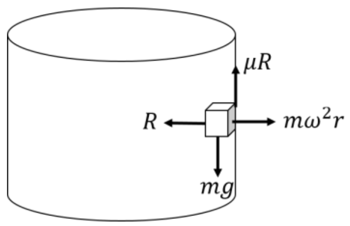
$$\Rightarrow \quad 2g = \left[\frac{l}{3} + \frac{l}{4}\right]\omega^2$$

$$\Rightarrow \quad 2g = \frac{7}{12}l\omega^2 \quad \Rightarrow \quad \omega = \sqrt{\frac{24}{7}\frac{g}{l}}$$

$$\Rightarrow \quad \omega = 2\sqrt{\frac{6}{7}\frac{g}{l}}$$

Q19. $R = m\omega^2 r$ …. (1)

$\mu R = mg$ …. (2)



$$\frac{(1)}{(2)} \ \Rightarrow\ \frac{1}{\mu} = \frac{\omega^2 r}{g}$$

$$\Rightarrow\ \omega = \sqrt{\frac{g}{\mu r}} = \sqrt{\frac{10}{0.4\times 1}}$$

$$\Rightarrow \quad \omega = \sqrt{25} = 5\,rad/s$$

Q20.

$A = A_0e^{-bt}$ ⇨ $\dfrac{A}{A_0} = e^{-bt}$ ⇨ $\dfrac{80}{100} = e^{-5b}$

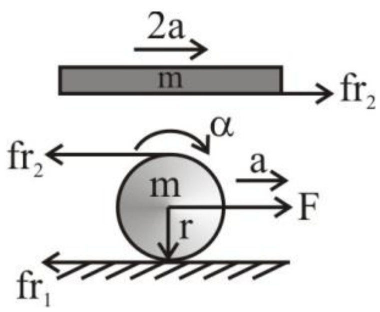
⇨ $0.8 = e^{-5b}$ ….(1)

$\dfrac{A}{A_0} = e^{-bt}$ ⇨ $\dfrac{\alpha}{100} = e^{-b(5+5)}$ ⇨ $\alpha = 100e^{-10b}$

⇨ $\alpha = 100\left(e^{-5b}\right)^2$ ….(2)

From eq (1) and (2): ⇨ $\alpha = 100(0.8)^2$ ⇨ $\boldsymbol{\alpha = 64}$

Q21.



For plank :

m.2a = fr_2 ………. (1)

For cylinder:

$ma = F - fr_1 - fr_2$ ……… (2)

$I\alpha = fr_1 r - fr_2 r$ ………….. (3)

$a = \alpha r$ ……….. (4)

From (3) & (4) :

$$\frac{mr^2}{2}\times\frac{a}{r} = (fr_1 - fr_2)\,r \ \Rightarrow\ \frac{ma}{2} = fr_1 - fr_2 \ \ \ldots\ldots (5)$$

$(1)\times 2 + (2) + (3)$:

$$4ma + ma + \frac{ma}{2} = 2fr_2 + F - fr_1 - fr_2 + fr_1 - fr_2$$

$$\Rightarrow \frac{11\,ma}{2} = F \Rightarrow \boldsymbol{a = \frac{2F}{11\,m}} \Rightarrow \boldsymbol{a = \frac{2F}{11 \times 2}}$$

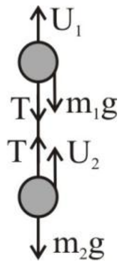
$$\Rightarrow \boldsymbol{a = \frac{F}{11}}$$

Acc. of plank $\Rightarrow \boldsymbol{2a = 2} \times \boldsymbol{\frac{F}{11}} = \frac{2F}{11} \Rightarrow$ n=2

Q22. $U_1 = T + m_1 g$

$$250\times10^{-6}\times\rho_l\times10 = T + 250\times10^{-6}\times0.8\times10^3\times10$$
.... (1)

$$U_2 + T = m_2 g \Rightarrow U_2 = m_2 g - T$$



$$\Rightarrow 250\times10^{-6}\times\rho_l\times10$$
$$= 250\times10^{-6}\times1.2\times10^3\times10 - T \quad ...... (2)$$

Equating (1) & (2) :

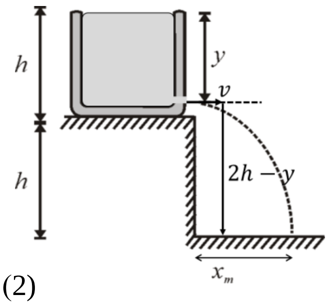
$$T + 250\times10^{-6}\times0.8\times10^3\times10$$
$$= 250\times10^{-6}\times1.2\times10^3\times10 - T$$

$$\Rightarrow 2T = 250\times10^{-6}(1.2-0.8)\times10^3\times10$$

$$\Rightarrow T = 0.5 = \frac{1}{2}\ \text{N}$$

Q23. Efflux velocity $v = \sqrt{2gy}$ .... (1)

For range to be found : $\left[h = \frac{1}{2} g\ \frac{x^2}{u^2}\right]$



$$\Rightarrow (2h - y) = \frac{1}{2}\, g\, \frac{x^2}{v^2}$$

$$\Rightarrow 2h - y = \frac{1}{2}\, g\, \frac{x^2}{(2gy)}$$

$$\Rightarrow x^2 = 4y\,(2h - y)$$

$$\Rightarrow x^2 = 8yh - 4y^2 \ .... (2)$$

For x to be maximum $\Rightarrow \frac{dx}{dy} = 0$

Differentiating eq. (2) $\Rightarrow 2x\frac{dx}{dy} = 8h - 8y$

$$\Rightarrow 0 = 8h - 8y \Rightarrow 8h = 8y \Rightarrow y = h$$

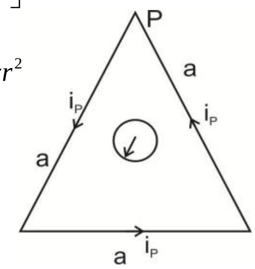
From eq. (2) $\Rightarrow x^2 = 8yh - 4y^2$

$$\Rightarrow x_{\max}^2 = 8\,h.h. - 4h^2 = 4h^2$$

$$\Rightarrow x_{\max} = 2\,h$$

Q24. $\phi_S = B_P A_S$

$$= \frac{\mu_0}{4\pi}\frac{i_p}{a}\left[4\times3\sin\frac{180^o}{3}\cdot\tan\frac{180^o}{3}\right]\pi r^2$$



$$= \frac{\mu_0}{4\pi}\frac{i_p}{a}\left[12\times\sin 60^o\tan 60^o\right]\pi r^2$$

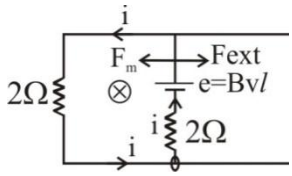
$$= \frac{\mu_0}{4}\frac{r^2}{a}\left[12\times\frac{\sqrt{3}}{2}\times\sqrt{3}\right]i_p$$

$$= \frac{\mu_0}{4}\frac{r^2}{a}[18]\,i_p = \left(\frac{9}{2}\mu_0\frac{r^2}{a}\right)i_p$$

$$\left.\begin{aligned}\phi_S &= \left(\frac{9}{2}\mu_0\frac{r^2}{a}\right)i_p\\ \text{also } \phi_S &= Mi_p\end{aligned}\right\} \Rightarrow M = \frac{9}{2}\mu_0\frac{r^2}{a} \Rightarrow \boldsymbol{n = 9}$$

Q25. $i = \frac{Bvl}{2+2} = \frac{2\times2\times1}{4}$

= 1A



$$Fext = Fm = ilB = 1\times1\times2 = 2N$$