JEE MAINS – 2019

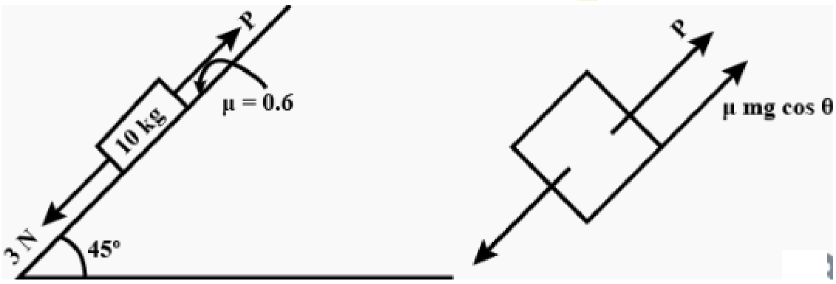
PHYSICS

1: Sol. (2)

From free body diagram,

Upward force $=$ Downward force

$$\text{mgsin}\theta + 3 = P + (\mu N)$$
$$\frac{10\times10}{\sqrt{2}} + 3 = P + \frac{0.6\times10\times10}{\sqrt{2}}$$
$$P = 32 \text{ N}$$



2. Sol. (3)

Change in Int energy should be same

In process ADC

$\Delta U = 60\text{-}30\text{=}30$ J

$$\Delta Q = \Delta U + \Delta W$$
$$\Delta Q = 30 + 10$$
$$\Delta Q = 40 \text{ J}$$

3: Sol. (2)

$$2f = 10 \text{ cm}$$
$$f = 5 \text{ cm}$$

Now due to glass plate, shift $= t\left(1-\frac{1}{\mu}\right) = 1.5\left(1-\frac{1}{1.5}\right) = 0.5$ cm

New object distance $= 10 - 0.5 = 9.5$

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$
$$v = \frac{uf}{u+f}$$
$$v = \frac{5\times 9.5}{5-9.5} = 10.55 \text{ cm}$$

The screen should be shifted by a distance 0.55 cm $\left(\text{or } \frac{5}{9}\right)$ away from the lens .

4: Sol. (2)

For small value of $d\theta$,

$$dA = \frac{r^2}{2} d\theta$$

Differentiating both side,

$$\frac{dA}{dt} = \frac{r^2}{2}\frac{d\theta}{dt}$$
$$\frac{dA}{dt} = \frac{r^2}{2}(\omega)$$
$$\frac{dA}{dt} = \frac{L}{2m} \qquad \left(L = mr^2\omega\right)$$

5: Sol. (2)

From velocity equation,

$$\frac{dx}{dt} = y \quad \& \quad \frac{dy}{dt} = x$$

So, we write above equation as,

$$x\,dx = y\,dy$$

Integrating both sides

$$y^2 = x^2 + C$$

6: Sol. (1)

Maximum speed is at equilibrium were,

$$F = kx$$

$$\Rightarrow x = \frac{F}{k}$$

$$Fx = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

Solving we get,

$$v = \frac{F}{\sqrt{mk}} = v_{max}$$

7: Sol. (2)

The formula of magnetic field for given case,

$$\vec{B} = \frac{\mu_0 i\theta}{4\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)\hat{k}$$

$$\vec{B} = \frac{\left(4\pi\times10^{-7}\right)(10)\left(\frac{\pi}{4}\right)}{4\pi}\left(\frac{1}{3\times10^{-2}} - \frac{1}{3\times10^{-2}}\right)\hat{k}$$

$$\left|\vec{B}\right| = \frac{\pi}{3}\times10^{-5} \approx 10^{-5}$$

8: Sol. (1)

E (along) axis of circular coil = $\dfrac{kQh}{\left(h^2+R^2\right)^{3/2}}$

for max value of E, $\dfrac{dE}{dh} = 0$

Differentiating E w.r.t. h, equating it to 0.

$$h = \frac{\mp R}{\sqrt{2}}$$

9: Sol. (2)

As we know that, $\lambda N = A$

So, we can take ratio,

$$\frac{\lambda_A}{\lambda_B}\frac{N_A}{N_B} = \frac{A_A}{A_B}$$

Now, substituting the values,

$$\frac{\lambda_A}{\lambda_B}\frac{(2N_B)}{N_B} = \frac{10}{20}$$
$$\frac{\lambda_A}{\lambda_B} = \frac{1}{4}$$
$$4\lambda_A = \lambda_B$$

10: Sol. (1)

Amount of charge,

$$Q = \frac{\Delta\phi}{R} = \frac{1}{10}A(B_f - B_i)$$
$$Q = \frac{1}{10}\times 3.5\times 10^{-3}\left(0.4\sin\frac{\pi}{2} - 0\right)$$
$$Q = \frac{1}{10}(3.5\times 10^{-3})(0.4-0)$$
$$Q = 1.4\times 10^{-4} = 140\mu C$$

11: Sol. (3)

The formula of drift velocity is,

$$v_d = \frac{i}{neA}$$

Drift velocity is calculated as,

$$v_d = \frac{i}{enA} = \frac{1.5}{1.6\times 10^{-19}\times 5\times 10^{-6}\times 9\times 10^{28}} = 0.02 \text{ mm/s}$$

12: Sol. (2)

Effective resistance between P & Q is,

$$R_{AB} = \frac{\left(\frac{3R}{2}\right)(R)}{\frac{3R}{2}+R} = \frac{3R}{5}$$

Effective resistance between A & B is,

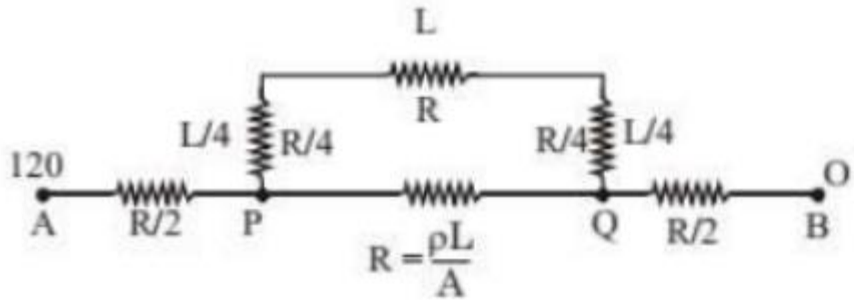
$$R_{eq} = \frac{R}{2}+\frac{R}{2}+\frac{3R}{5}$$

$$R_{eq} = \frac{8R}{5}$$

$$\frac{\Delta T}{R_{eq.}} = I = \frac{(120)5}{8R} = \frac{120\times 5}{8R}$$

$$\Delta T_{PQ} = \frac{120\times 5}{8R}\times\frac{3}{5}R$$

$$\Delta T_{PQ} = \frac{360}{8} = 45^{\circ}C$$



13: Sol. (3)

Applying law of conservation moment

$$P_i = P_f$$

$$mu = (2m+M)v_f$$

$$\frac{mu}{2m+M} = v_f$$

The energy relation is given as,

$$K_f = \frac{1}{6} K_i$$

Writing the energy in form of momentum and solving,

$$\frac{1}{2}\left(\frac{P^2}{2m+M}\right) = \frac{1}{6}\left(\frac{1}{2}\right)\left(\frac{P^2}{m}\right)$$

$$6m = 2m + M$$
$$4m = M$$

14: Sol. (4)

The formula of v_{rms} is,

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

or $v_{rms} \propto \frac{1}{\sqrt{M}}$

The ratio of the rms speeds,

$$\frac{(v_{rms})He}{(v_{rms})Ar} = \sqrt{\frac{M_{Ar}}{M_{He}}} = \sqrt{\frac{40}{4}}$$

$$\frac{(v_{rms})He}{(v_{rms})Ar} = \sqrt{10} = 3.16$$

15: Sol. (2)

According to photoelectric effect,

$$\frac{hc}{\lambda_1} = \phi + \frac{1}{2} m(2v)^2$$

$$\frac{hc}{\lambda_2} = \phi + \frac{1}{2} mv^2$$

Now taking ratio,

$$\frac{\frac{hc}{\lambda_1}-\phi}{\frac{hc}{\lambda_2}-\phi}=4$$

$$\frac{hc}{\lambda_2}-\phi=\frac{4hc}{\lambda_2}-4\phi$$

$$\frac{4hc}{\lambda_2}-\frac{hc}{\lambda_1}=3\phi$$

$$\phi=\frac{1}{3}hc\left(\frac{4}{\lambda_2}-\frac{1}{\lambda_1}\right)$$

The work function of the metal is calculated as,

$$\phi=\frac{1}{3}\times 1240\left(\frac{4\times 350-540}{350\times 540}\right)$$
$$\phi=1.8\text{eV}=1.88\text{eV}$$

16: Sol. (2)

Applying junction rule,

$$\frac{V-20}{2}+\frac{V-10}{4}+\frac{V-0}{2}=0$$
$$V\left(\frac{1}{2}+\frac{1}{4}+\frac{1}{2}\right)=\left(\frac{20}{2}+\frac{10}{4}\right)$$
$$\frac{5V}{4}=\frac{50}{4}$$
$$V=10\text{ V}$$

The value of current through resister is,

$$I=\frac{10}{2}=5\text{ A}$$

17: Sol. (4)

Net force of $+Q$, $F_O = 0$

The net force is calculated as,

$$F_O = \frac{kQq}{\left(\frac{d}{2}\right)^2} + \frac{kQ^2}{\left(\frac{d}{2}+\frac{d}{2}\right)^2} = 0$$

$$\frac{q}{\left(\frac{d}{2}\right)^2} = \frac{-Q}{(d)^2}$$

$$q = \frac{-Q}{4}$$

18: Sol. (2)

$$\frac{E}{B} = c$$

$$B = \frac{E}{c}$$

$$B = \frac{6.3\times10^{27}}{3\times10^{8}}$$

$$B \approx 2\times10^{19}\ \text{T}$$

19: Sol. (4)

$$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2}$$

Simplifying we get $\frac{I_1}{I_2} = \frac{25}{9}$

20: Sol. (2)

$$R=\frac{\rho l\times l}{a\times l}=\frac{\rho l^2}{V}$$

$$R\propto l^2$$

$$\frac{dR}{R}=2\left(\frac{dl}{l}\right)$$

$$\frac{dR}{R}\times100=2\left(\frac{dl}{l}\times100\right)$$

$$\frac{dR}{R}\times100=2(0.5)$$

$$\frac{dR}{R}\times100=1\%$$

21: Sol. (2)

From diagram,

$$C_1P=\frac{L\sin\theta}{2}$$

$$C_2N=\frac{L\cos\theta}{2}-L\sin\theta$$

Let mass of one rod is m. Balancing torque about hinge point .

Clockwise torque = anti - clockwise torque

$$mg(C_1P)=mg(C_2N)$$

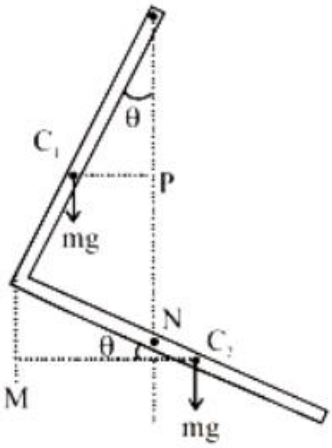
$$mg\left(\frac{L\sin\theta}{2}\right)=mg\left(\frac{L\cos\theta}{2}-L\sin\theta\right)$$

$$\frac{L\sin\theta}{2}+L\sin\theta=\frac{L\cos\theta}{2}$$

$$\frac{3\sin\theta}{2}=\frac{\cos\theta}{2}$$

$$\tan\theta=\frac{1}{3}$$

$$\theta=\tan^{-1}\left(\frac{1}{3}\right)$$



22: Sol. (2)

$$\Delta I = I\alpha \,....(i)$$

$$\Delta I = \frac{IF}{AY}\,....(i)$$

From $(i)\&(ii)$,

$$I\alpha\Delta T = \frac{FI}{AY}$$

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

23: Sol. (1)

$$\left\{\frac{y}{d} = \frac{x}{a}\right\}....1$$

$$dC_2 = \frac{\varepsilon_0 adx}{(d-y)}$$

$$dC_1 = \frac{K\varepsilon_0 adx}{y}$$

$$dC_{eq} = \left(\frac{dC_1.dC_2}{da + dC_2}\right) = \frac{\varepsilon adx}{\left(\frac{C_1}{K}\right) + \left(\frac{d-y}{I}\right)}.....2$$

$$C_{eq}=\int_0^a \frac{\varepsilon_0 a dx}{\frac{y}{k}+\frac{(d-y)}{I}}=\frac{k\varepsilon_0 a^2 Ink}{d(k-1)}$$

24: Sol. (1)

$\sigma = ne\mu$

$$\Rightarrow \rho=\frac{1}{ne\mu}=\frac{1}{10^{19}\times 1.6\times 10^{-19}\times 1.6}=0.4\Omega\text{m}$$

25: Sol. (1)

$$v=\sqrt{\frac{ma}{M}}$$

$$v\propto\sqrt{a_{eft}}$$

The wave velocity formula is,

$$v=\sqrt{\frac{T}{\mu}}=\sqrt{\frac{Mg}{\mu}}$$

Therefore,

$$60=\sqrt{\frac{Mg}{\mu}} \qquad (i)$$

$$60.5=\sqrt{\frac{Mg'}{\mu}} \qquad (ii)$$

Dividing equation (ii) by (i) ,

$$\frac{60.5}{60}=\frac{\sqrt{\frac{M\sqrt{a^2+g^2}}{\mu}}}{\sqrt{\frac{Mg}{\mu}}}$$

$$\left(\frac{60.5}{60}\right)^4 = \frac{a^2+g^2}{g^2}$$

$$a = g\sqrt{\left(\frac{60.5}{60}\right)^4 - 1}$$

$$a = \frac{g}{5.44} \approx \frac{g}{5}$$

26: Sol. (4)

Colour code :

Red violet orange silver

$$\begin{aligned} R &= 27\times10^3\Omega\pm10\% \\ &= 27K\Omega\pm10\% \end{aligned}$$

27: Sol. (2)

Coercivity $= H = \dfrac{B}{\mu_0}$

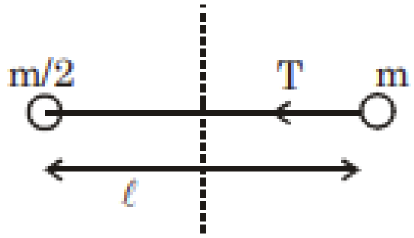
$$= ni = \frac{N}{l}i = \frac{100}{0.2}\times5.2$$

$$= 2600\ \text{A/m}$$

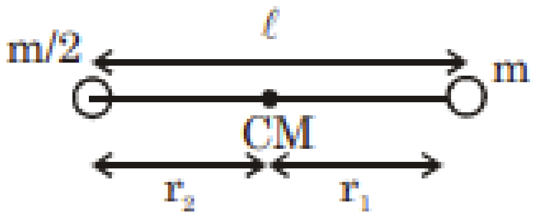
28: Sol. (4)

$$\omega = \sqrt{\frac{k}{I}}$$

$$\omega = \sqrt{\frac{3k}{m\ell^2}} \quad \left[\because I = \mu\ell^2 = \frac{\frac{m^2}{2}}{\frac{3m}{2}}\ell^2 = \frac{m\ell^2}{3}\right]$$



$\Omega = \omega\theta_0 =$ average velocity



$$\frac{r_1}{r_2} = \frac{1}{2} \Rightarrow r_1 = \frac{\ell}{3}$$

$$T = m\Omega^2 r_1$$

$$= m\Omega^2 \frac{\ell}{3}$$

$$= m\omega^2 \theta_0{}^2 \frac{\ell}{3}$$

$$= m\frac{3k}{m\ell^2}\theta_0{}^2\frac{\ell}{3}$$

$$= \frac{k\theta_0{}^2}{\ell}$$

29: Sol. (1)

$C < i_b$

Here i_b is "brewester angle" and C is critical angle.

since $\tan i_b = \mu_{0_{rel}} = \frac{1.5}{\mu}$

$$\therefore \sin i_b = \frac{1.5}{\sqrt{\mu^2 + 1.5^{\ 2}}}$$

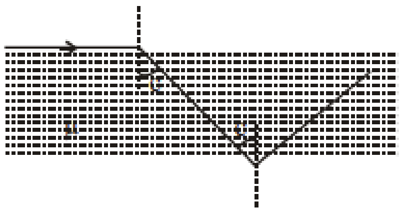
$\sin c < \sin i_b$,

$$\frac{1}{\mu} < \frac{1.5}{\sqrt{\mu^2 + 1.5^2}}$$

$$\sqrt{\mu^2 + 1.5^2} < 1.5\times\mu$$

$$\mu^2 + 1.5^2 < 1.5\times\mu^2$$

$$\mu < \frac{3}{\sqrt{5}}$$



slab μ = 1.5

30: Sol. (3)

Equivalent dipole of given loop

$$F = m\cdot\frac{dB}{dr}$$

Now,

$$\frac{dB}{dx} = \frac{d}{dx}\left(\frac{\mu_0 I}{2\pi x}\right)$$

$$\propto \frac{1}{x^2}$$

So, $F \propto \frac{M}{x^2} \quad \because M = NIA$

$$F \propto \left(\frac{a}{d}\right)^2$$