JEE MAIN – 2020

PHYSICS

SECTION A

1. Sol. (4)

Intensity after polarisation through polaroid $= I_0 \cos^2 \varphi$

So, $0.1I_0 = I_0 \cos^2 \varphi$

$$0.1I_0 = I_0 \cos^2 \varphi$$
$$\cos^2 \varphi = 0.1$$
$$\cos \varphi = 0.316$$

Since, $\cos\varphi < \cos 45^\circ$ therefore, $\varphi > 45^\circ$. If the light is passing at 90° from the plane of polaroid, then its intensity will be zero.

Then, $\theta = 90^\circ - \varphi$ therefore, θ will be less than 45°.

2. Sol. (3)

It will behave as a NOT gate. Hence gives reversible operation.

A	B
0	1
1	0

3. Sol. (4)

$$P = Fv + Mgv$$
$$P = 4000v + 20000\, v$$
$$60 \times 246 = 4000\, v + 20000\, v$$
$$v = 1.865 \simeq 1.9 \text{ m/s}$$

4. Sol. (3)

The equation of current is,

$I = I_0 t - I_0 t^2$

The formula of flux is,

$\phi = \text{BA}$
$\phi = \mu_0 nIA$

The induced EMF is,

$V_R = -\frac{d\phi}{dt}$
$V_R = -\mu_0 nAI_0(1-2t)$

at $t = \frac{1}{2}\text{s}, \Rightarrow V_R = 0$

The value of induced current,

$I_R = \frac{V_R}{R} = \frac{-\mu_0 nAI_0(1-2t)}{R}$

When $t > \frac{1}{2}\text{s}$, the direction of current will change.

5. Sol. (3)

$\gamma_{mix} = \frac{n_1 C_{p1} + n_2 C_{p2}}{n_1 C_{v1} + n_2 C_{v2}}$

$\gamma_{mix} = \frac{n_1 \frac{\gamma_1}{\gamma_1 - 1} + n_2 \frac{\gamma_2}{\gamma_2 - 1}}{\frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}}$

$n_1 = 2, \gamma_1 = \frac{5}{3}, n_2 = 3, \gamma_2 = \frac{4}{3}$

On solving above equation,

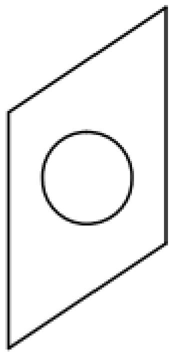
$\gamma_{mix} = 1.42$

6. Sol. (1)

Correct Answer: A

As, magnetic field lines forms a closed loop, hence each line from circular area will pass through outer area

in opposite direction hence, $\phi_i = -\phi_0$



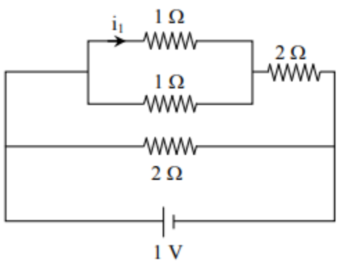
7. Sol. (3)

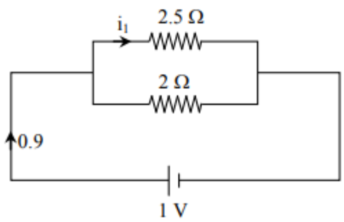
The circuit diagram is shown below,

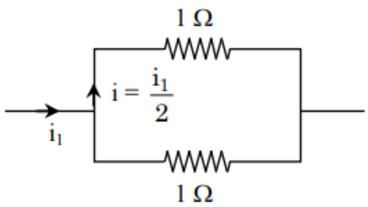
The current flowing through the battery is,

$$I = \frac{V}{R_{eq}} = 1\left(\frac{2}{5} + \frac{1}{2}\right)$$
$$I = 0.9 \text{ A}$$

$$i_1 = \frac{I(2)}{4.5} = \frac{0.9(2)}{4.5} = 0.4 \text{ A}$$
$$i = \frac{i_1}{2} = \frac{0.4}{2} = 0.2 \text{ A}$$







8. Sol. (1)

Electrical field due to an infinite sheet is given by, $E = \dfrac{\sigma}{2\varepsilon_0}$ where σ is the surface charge density.

$\vec{E}_1$ is the electric field due to the first sheet and can be given as:

$$\vec{E}_1 = \frac{\sigma}{2\epsilon_0}\left[-\cos 60^\circ\,\hat{x} - \sin 60^\circ\,\hat{y}\right]$$

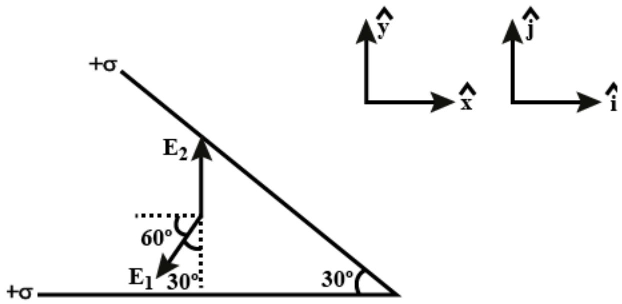
E_2 is the electric field due to the second sheet and can be given as:

$$\vec{E}_2 = \frac{\sigma}{2\epsilon_0}\hat{y}$$

Net electric field is calculated as,

$$\vec{E}_1 + \vec{E}_2 = \left(-\frac{\sigma}{4\epsilon_0}\hat{x} - \frac{\sqrt{3}\sigma}{4\epsilon_0}\hat{y}\right) + \frac{\sigma}{2\epsilon_0}\hat{y}$$

$$\vec{E}_1 + \vec{E}_2 = \frac{\sigma}{2\epsilon_0}\left[\left(1 - \frac{\sqrt{3}}{2}\right)\hat{y} - \frac{\hat{x}}{2}\right]$$



9. Sol. (4)

$$E_0 = B_0 c$$
$$E_0 = \left(3\times10^{-8}\right)\left(3\times10^{8}\right)\sin\left(\omega t + kx\right)$$
$$E_0 = 9\sin\left(1.6\times10^{3}x + 48\times10^{10}t\right)$$

10. Sol. (2)

$$\frac{2\pi r}{v} \propto \frac{n^2/z}{z/n}$$
$$\frac{r}{v} \propto \frac{n^3}{z^2}$$
$$f \propto \frac{n^3}{z^2}$$
$$f_2 = \frac{1}{8} f_1$$
$$f_2 = \frac{1}{8}\left(\frac{1}{1.6\times10^{-16}}\right)$$
$$f_2 = 7.8\times10^{14}\,\text{Hz}$$

11. Sol. (4)

Spring mass damped oscillator,

$$\frac{d^2x}{dt^2} + \frac{b}{m}\left(\frac{dx}{dt}\right) + \frac{kx}{m} = 0 \qquad (i)$$

For LC oscillations

$$\frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{LC} = 0 \qquad (ii)$$

Comparing Equations (i) and (ii),

$$b \leftrightarrow R$$
$$L \leftrightarrow m$$
$$\frac{1}{C} \leftrightarrow k$$

12. Sol. (4)

For second minima,

$$d\sin\theta = 2\lambda$$
$$d\sin 60^\circ = 2\lambda$$

$$d\left(\frac{\sqrt{3}}{2}\right) = 2\lambda \quad (i)$$

For 1st minima,

$$d\sin\theta = \lambda$$

$$\sin\theta = \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$$

$$\theta = 25^0$$

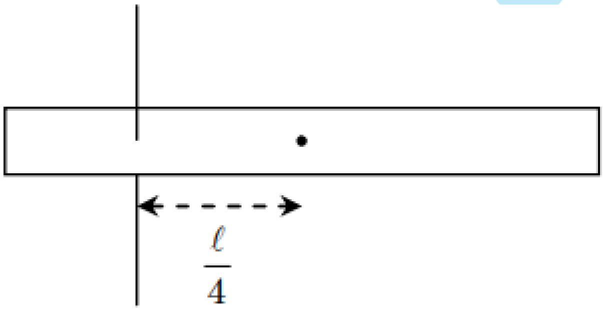
13. Sol. (1)

$$I = \frac{Ml^2}{12} + M\left(\frac{l}{4}\right)^2$$

$$I = \frac{7Ml^2}{48}$$

$$Mk^2 = \frac{7Ml^2}{48}$$

$$k = l\sqrt{\frac{7}{48}}$$



14. Sol. (1)

Applying energy conservation,

$$K_i + U_i = K_f + U_f$$

$$\frac{mu^2}{2} + \left(-\frac{GMm}{R}\right) = \frac{mv^2}{2} - \frac{GMm}{2R}$$

$$v = \sqrt{u^2 - \frac{GM}{R}} \qquad (i)$$

By momentum conservation, we have

$$\frac{m}{10}v_T = \frac{9m}{10}\sqrt{\frac{Gm}{2R}}$$

$$\& \ \frac{mv_r}{10} = mv$$

From equation (i),

$$\frac{mv_r}{10} = m\sqrt{u^2 - \frac{GM}{R}}$$

Kinetic energy of rocket is calculated as,

$$K.E = \frac{m}{2}\left(v_T{}^2 + v_r{}^2\right)$$

$$K.E = \frac{m}{20}\left(\frac{81GM}{2R} + 100u^2 - 100\frac{GM}{R}\right)$$

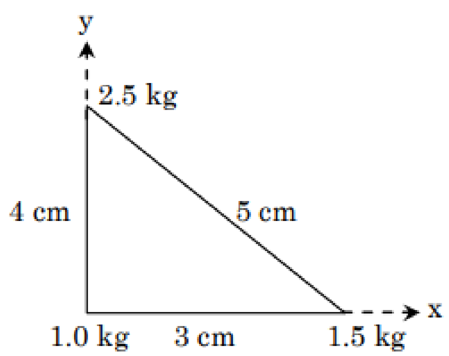
$$K.E = \frac{m}{20}\left(100u^2 - \frac{119GM}{2R}\right)$$

$$K.E = 5m\left(u^2 - \frac{119GM}{200R}\right)$$

15. Sol. (1)

$$x_{cm} = \frac{(2.5\times0)+(1.5\times3)+(1\times0)}{2.5+1.5+1} = 0.9 \text{ cm}$$

$$y_{cm} = \frac{(2.5\times4)+(1.5\times0)+(1\times0)}{2.5+1.5+1} = 2 \text{ cm}$$



16. Sol. (1)

$\text{M.P} = 375$

$f_0 = 5 \text{ mm}$

Case-I

If final image is at infinity,

$$M.P = \frac{L_0}{f_0}\left(\frac{D}{f_e}\right)$$

$$375 = \frac{150}{5}\left(\frac{250}{f_e}\right)$$

$$f_e = 20$$

Case-II

Near – point adjustment

$$M.P = \frac{L_0}{f_0}\left(1 + \frac{D}{f_e}\right)$$

$$375 = \frac{150}{5}\left(1 + \frac{250}{f_e}\right)$$

$$f_e = 22 \text{ mm}$$

17. Sol. (1)

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{Y\Delta L}{L}\left(\frac{A}{m/L}\right)}$$

$$v = \frac{v^2 m}{YA}$$

$$v = \frac{90 \times 90 \times 6 \times 10^{-3}}{16 \times 10^{11} \times 1 \times 10^{-6}}$$

$$v \approx 0.03 \text{ mm}$$

18. Sol. (3)

$$P_iV_i^{\gamma} = P_fV_f^{\gamma}$$

$$P_f = \frac{P_iV_i^{\gamma}}{V_f^{\gamma}} = \frac{10^5}{3^{1.4}}$$

We know that,

$$\Delta W = \frac{P_fV_f - P_iV_i}{1-\gamma}$$

$$\Delta W = \frac{\left(\frac{10^5}{3^{1.4}}\right)\left(3\times10^{-3}\right)-\left(10^5\times10^{-3}\right)}{1-1.4}$$

$$\Delta W \approx 90.5 \text{ J}$$

19. Sol. (2)

Energy conservation,

$$mgh = \frac{mv^2}{2} + \frac{I\omega^2}{2} \qquad (i)$$

$$\omega = \frac{v}{r} \qquad (ii)$$

Solving (i) & (ii), we get

$$\omega = \frac{1}{r}\sqrt{\frac{4gh}{3}}$$

20. Sol. (2)

As k is variable we take a plate element of Area A and thickness dx at distance x

Capacitance of element,

$$dC = \frac{(A)k(1+\alpha x)\varepsilon_0}{dx}$$

$$\frac{1}{C_{eq}} = \int \frac{1}{dC_1}$$

$$\frac{1}{C_{eq}} = \int_0^d \frac{dx}{kA(1+\alpha x)\varepsilon_0}$$

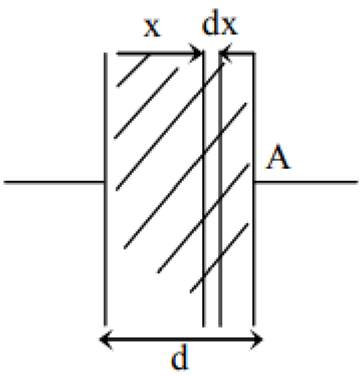
$$\frac{1}{C_{eq}} = \frac{1}{\varepsilon_0 kA\alpha}\ln(1+\alpha d)$$

Using expansion of $\ln(1+x)$ keeping $x << 1$,

$$\frac{1}{C_{eq}} = \frac{1}{\varepsilon_0 kA\alpha}\left(\alpha d - \frac{(\alpha d)^2}{2}\right)$$

$$C_{eq} = \frac{\varepsilon_0 kA}{d}\left(1 - \frac{\alpha d}{2}\right)^{-1}$$

$$C_{eq} = \frac{\varepsilon_0 kA}{d}\left(1 + \frac{\alpha d}{2}\right)$$



SECTION B

21. Sol. 60

For non- isotropic,

$$\gamma = \alpha_x + \alpha_y + \alpha_z$$

$$\gamma = \left(5\times10^{-5}\right) + \left(5\times10^{-6}\right) + \left(5\times10^{-6}\right)$$

$$\gamma = 60\times10^{-6}$$

Comparing, we get, $C = 60$

22. Sol. 175

Area of the plane is ,

$\vec{A} = 25\hat{k} + 25\hat{k}$

Magnetic field in the region, $B = \left(3\hat{i} + 4\hat{k}\right)\text{T}$

The flux is calculated as,

$$\phi = \vec{B}.\vec{A}$$
$$\phi = \left(3\hat{i} + 4\hat{k}\right)\left(25\hat{i} + 25\hat{k}\right)$$
$$\phi = 175 \text{ Wb}$$

23. Sol. 600

The formula of efficiency is,

$$\eta = 1 - \frac{T_L}{T_H}$$
$$\eta = 1 - \frac{300}{900} = \frac{2}{3}$$

$$\frac{w}{Q_s} = \frac{2}{3}$$
$$Q_s = \frac{3w}{2}$$
$$Q_s = \frac{3 \times 1200}{2}$$
$$Q_s = 1800 \text{ J}$$

Rejected $= Q_s - w = 1800 - 1200 = 600 \text{ J}$

24. Sol. 10

Change in height $= 1 \text{ m}$

$$= 1 \text{ m}$$
$$K.E = \Delta P.E$$
$$K.E = mgh$$
$$K.E = 1 \times 10 \times 1 = 10 \text{ J}$$

25. Sol. 11

Energy of Photon $= \frac{1240}{310} = 4 \text{ eV}$

Energy is greater than work function,

No. of photons $= \frac{\text{intensity}}{\text{Energy of one photon}} = \frac{6.4\times10^{-5}}{4\times1.6\times10^{-19}} = 10^{14}$

Total number of electron, $= \frac{10^{14}}{10^{3}} = 10^{11}$.

$\therefore x = 11.$