1. An elliptical ring of semi major and semi minor axis $a$ and $b$ respectively, rotates about diameter with angular speed $\omega$ in uniform magnetic field $B$. Resistance of elliptical ring $R$. Average power produced will be:

$$\text{Ans. (1)}$$

$$\text{Sol.}$$

$$\varepsilon = NAB\omega \cos\omega t$$

$$\langle P \rangle = \frac{\langle \varepsilon^2 \rangle}{R}$$

$$= \frac{N^2 A^2 B^2 \omega^2 \cos^2 \omega t}{R}$$

$$= \frac{N^2 A^2 B^2 \omega^2}{R} \left( \frac{1}{2} \right)$$

$$= \frac{N^2 \pi^2 a^2 b^2 B^2}{2R} (\omega^2)$$

2. A system consists of 2 isolated conducting spheres, kept at infinite distance. Sphere $X$ has radius $\frac{2R}{3}$ and charge $12 \mu C$ and sphere $Y$ has radius $\frac{R}{3}$ and charge $-3 \mu C$. If the switch is closed, then find charges on $X$ & $Y$.

$$\text{(1) } 3 \mu C \text{ and } 6 \mu C \text{ respectively}$$
$$\text{(2) } 6 \mu C \text{ on both}$$
$$\text{(3) } 6 \mu C \text{ and } 3 \mu C$$
$$\text{(4) None of these}$$

$$\text{Ans. (3)}$$
3. Pressure inside two soap bubbles is 1.01 atm and 1.02 atm. Find the ratio of their volume.

(1) 8 : 1
(2) 4 : 1
(3) 2 : 1
(4) 3 : 1

Ans. (1)

Sol. \( \frac{P_{\text{excess}}}{P_{\text{excess}}} = 0.01 = \frac{4T}{R_1} \)
\( \frac{P_{\text{excess}}}{P_{\text{excess}}} = 0.02 = \frac{4T}{R_2} \)

Dividing,
1 \( R_2 \)
2 \( R_1 \)
\( R_1 = 2R_2 \)

\[ \frac{V_1}{V_2} = \frac{R_1^3}{R_2^3} = \frac{8R_2^3}{R_2^3} = 8 : 1 \]

4. A diode has potential drop of 0.5 volt in forward bias. The maximum current that can flow through diode is 10 mA. Then find the resistance connected in series with diode so that set up can be connected to a battery of 1.5 volt:

(1) 100Ω
(2) 50Ω
(3) 25Ω
(4) 10Ω

Ans. (1)

Sol.

\[ \begin{align*}
V_{\text{diode}} &= 0.5 \text{ volt} \\
V_B &= 1.5 - 0.5 = 1 \text{ volt} \\
iR &= 1 \\
R &= \frac{1}{i} = \frac{1}{10^{-2}} = 100 \Omega
\end{align*} \]
5. A triatomic molecule in the shape of a triangle can be assumed that atoms are at vertices of triangle and joined by mass less rods. Internal energy of 1 mole at temperature T is:

\[ U = \frac{5}{2}RT \]

\[ U = \frac{9}{2}RT \]

\[ U = \frac{3}{2}RT \]

\[ U = 3RT \]

(1) \( \frac{5}{2}RT \)

(2) \( \frac{9}{2}RT \)

(3) \( \frac{3}{2}RT \)

(4) \( 3RT \)

Ans. (1)

Sol. \( U = \frac{5}{2}RT = \frac{9}{2}RT = 3RT \)

6. A satellite is revolving near by earth of radius = \( R_e \). If its velocity is increased \( \sqrt{\frac{3}{2}}V \) where \( V \) is orbital speed of satellite then find maximum distance of satellite from the center of earth.

(1) \( R_e \)

(2) \( 2R_e \)

(3) \( 3R_e \)

(4) \( 4R_e \)

Ans. (3)

Sol.

\[ V = \sqrt{\frac{\frac{3}{2}VR_e}{\frac{3}{2}VR_e}} \]

\[ V = \frac{GM}{\sqrt{R_e}} \]

From energy conversation

\[ -\frac{GMm}{R_e} + \frac{1}{2}m\left(\sqrt{\frac{3}{2}V}\right)^2 = -\frac{GMm}{R_{\text{max}}} + \frac{1}{2}mV_{\text{min}}^2 \]

...(i)

From angular momentum conversation

\[ \sqrt{\frac{3}{2}}VR_e = V_{\text{min}}R_{\text{max}} \]

...(ii)

Eliminating \( V_{\text{min}} \) from equation (i) and (ii) we get

\[ R_{\text{max}} = 3R_e \]
7. When wavelength of light incident on metal surface changes from 500 nm to 200 nm, maximum possible kinetic energy of emitted photo-electrons becomes three times then find the work function of metal.

(1) 0.61 eV  (2) 0.65 eV  (3) 0.50 eV  (4) 0.25 eV

Ans. (1)

Sol. 

\[ KE_{\text{max}} = \frac{hc}{\lambda} \phi = \frac{hc}{500} \phi \] 

\[ \text{……(i)} \]

Now, 

\[ 3KE_{\text{max}} = \frac{hc}{200} \phi \] 

\[ \text{……(ii)} \]

From equation (i) and (ii)

\[ \frac{(ii)}{(i)} = \frac{3}{1} = \frac{\frac{hc}{200} \phi}{\frac{hc}{500} \phi} \]

Put the value of \( hc = 1237.5 \) and solving \( \phi = 0.61 \) eV

8. An observer’s line of sight is at P, when container of diameter 30 cm and height 45 cm is empty. If this container is filled with a liquid up to 30 cm height he is able to see the edge of container. Find refractive index of liquid.

\[ (1) \sqrt{\frac{5}{2}} \quad (2) \frac{5}{\sqrt{2}} \quad (3) \frac{\sqrt{5}}{2} \quad (4) \frac{5}{2} \]

Ans. (1)
From Shell's Law
\[ \mu \times \sin i = 1 \times \sin r \]
\[ \mu = \frac{\frac{15}{\sqrt{15^2 + 30^2}}}{1 \times \sin 45^\circ} \]
\[ \mu = \frac{\frac{15}{15^2 + 30^2}}{1 \times \sin 45^\circ} \]

9. A mass of 2 kg suspended by a string of mass 6 kg. A wave of wavelength 6 cm is produced at the bottom of string. The wavelength of wave at the top end of string will be.

(1) 6 cm (2) 18 cm (3) 12 cm (4) 24 cm

Ans. (3)

Sol.
\[ V = f \lambda \]
\[ \frac{V_1}{\lambda_1} = \frac{V_2}{\lambda_2} \]
\[ \lambda_2 = \frac{V_2}{V_1} \lambda_1 = \sqrt{\frac{T_2}{T_1}} \lambda_1 \]
\[ T_2 = 8g \text{ (Top)} \]
\[ T_1 = 2g \text{ (Bottom)} \]
\[ \sqrt{\frac{8g}{2g}} \lambda_1 = 2 \lambda_1 = 12 \text{ cm} \]
10. Screw gauge of pitch 0.1 cm and 50 division on circular scale, measure thickness of an object. Which of the following measurement is possible for thickness
   (1) 2.123 cm   (2) 2.124 cm   (3) 2.125 cm   (4) 2.127 cm
   **Ans.** (2)
   **Sol.** Thickness = M.S. Reading + Circular Scale Reading (L.C.)
   Here, LC = \( \frac{0.1}{50} \) = 0.002 cm per division

11. A bowling machine projects a ball of mass 0.15 kg in upward direction. If ball displaced along bowling machine 0.2m and released. After the released from bowling machine ball attain 20 m height then find the force exerted by bowling machine on the ball.
   (1) 145.5 N   (2) 165.5 N   (3) 175.5 N   (4) 151.5 N
   **Ans.** (4)
   **Sol.** From work energy theorem \( F(0.2) - mg(20.2) = 0 \)
   \[
   F = mg\left(\frac{20.2}{0.2}\right)
   = mg\left(\frac{202}{2}\right)
   = 0.15 \times 10 \times \frac{202}{2}
   = 15 \times 10.1 \text{ N}
   = 151.5 \text{ N}
   \]

12. Total 750 \( \mu \text{F} \) charge flows through circuit then charge flow through \( C_2 \) capacitance will be.

   ![Circuit Diagram]

   (1) 160   (2) 590   (3) 450   (4) 630
   **Ans.** (2)
13. A man of mass 80 kg is standing on a circumference of disk of mass 200 kg. Disk is rotating about vertical axis with angular speed 5 rev/second. Find angular speed of disk if man reaches at the centre of disk.

(1) 3 rev/sec. (2) 6 rev/sec. (3) 9 rev/sec. (4) 12 rev/sec.

**Ans.** (3)

**Sol.**

\[
\left( \frac{mR^2}{2} \right) \omega = \frac{MR^2}{2} \omega' \]

\[
\left( 80 + \frac{200}{2} \right) \times 5 = \frac{200}{2} \omega'
\]

\[\omega' = 9 \text{ rev/sec.} \]

14. Magnetic field at centre of hexagonal coil having 50 turns, side 10 cm and current i in the units of \( \frac{\mu_0 i}{\pi} \) will be:

(1) \( 500\sqrt{3} \) (2) \( 250\sqrt{3} \) (3) \( 300\sqrt{3} \) (4) \( 400\sqrt{3} \)

**Ans.** (1)
Sol. \[ B = 50 \times 6 \times \frac{\mu_0 l}{4 \pi} \left( \frac{10}{100} \right) \cos 30^\circ \left[ \sin 30^\circ + \sin 30^\circ \right] \]

\[ 2 \times 75 \times 10 \frac{\mu_0 l}{\sqrt{3} \pi} \left( \frac{1}{2} + \frac{1}{2} \right) \]

\[ 1500 \frac{\mu_0 l}{\pi} = 500\sqrt{3} \frac{\mu_0 l}{\pi} \]

\[ 500\sqrt{3} \text{ Ans.} \]

15. Find maximum angular displacement of rod. If particle sticks after collision.

(1) 63° (2) 69° (3) 53° (4) 59°

Ans. (1)

Sol. Angular momentum

\[ mvl = \left( \frac{m^2 l^2 + 2m^2 l^2}{3} \right) \omega \]

\[ mvl = \frac{5}{3} m^2 l^2 \omega \]

\[ \omega = \frac{3v}{5l} \]

\[ \frac{1}{2} l_0^2 = 2mg \left( \frac{\ell}{2} \right) \left( 1 - \cos \theta \right) + mg \left( 1 - \cos \theta \right) \]

\[ \frac{1}{2} \left( \frac{5}{3} m^2 l^2 \right) \left( \frac{9v^2}{25/l^2} \right) = 2mg \left( 1 - \cos \theta \right) \]

\[ \frac{3}{5 \times 2} mv^2 = 2mg \left( 1 - \cos \theta \right) \]

\[ \frac{3}{10} \times \frac{36}{2 \times 10} = 1 - \cos \theta \]

\[ 1 - \frac{27}{50} = \cos \theta \]

\[ \cos \theta = \frac{23}{50} \]

\[ \theta = 63^\circ \]
16. The hollow cylinder of length $\ell$ and inner and outer radius $R_1$ and $R_2$ respectively. Find resistance of cylinder if current flows radially outward in the cylinder. Resistivity of material of cylinder is $\rho$.

\[
\begin{align*}
(1) & \quad \frac{\rho}{\pi\ell} \left(\frac{R_2}{R_1}\right) \\
(2) & \quad \frac{\rho}{4\pi\ell} \left(\frac{R_2}{R_1}\right) \\
(3) & \quad \frac{\rho}{3\pi\ell} \left(\frac{R_2}{R_1}\right) \\
(4) & \quad \frac{\rho}{2\pi\ell} \left(\frac{R_2}{R_1}\right) \\
\end{align*}
\]

Ans. (4)

Sol.

\[
\text{The resistance of small element}
\]

\[
\Delta R = \frac{\rho dr}{2\pi\ell}
\]

\[
R = \frac{\rho}{2\pi\ell} \int_0^{R_2} \frac{dr}{r}
\]

\[
R = \frac{\rho}{2\pi\ell} \ln \frac{R_2}{R_1}
\]

17. 1$\mu$C charge moves with the velocity $\vec{v} = 4\hat{i} + 6\hat{j} + 3\hat{k}$ in uniform magnetic field. $\vec{B} = 3\hat{i} + 4\hat{j} - 3\hat{k} \times 10^{-3}$.

Force experienced by charged particle in units of $10^{-9}$ N will be:

\[
\begin{align*}
(1) & \quad -0.3\hat{i} + 2.1\hat{j} + 0.4\hat{k} \\
(2) & \quad -30\hat{i} + 21\hat{j} - 2\hat{k} \\
(3) & \quad -0.03\hat{i} + 0.21\hat{j} + 0.04\hat{k} \\
(4) & \quad -3\hat{i} + 0.21\hat{j} + 0.4\hat{k}
\end{align*}
\]

Ans. (2)

Sol.

\[
\vec{F} = 10^{-6} \times 10^{-3} \begin{vmatrix}
\hat{i} & \hat{j} & \hat{k} \\
4 & 6 & 3 \\
3 & 4 & -3
\end{vmatrix}
\]

\[
= 10^{-9} \left[(4 \times -30) - (6 \times -9) + (3 \times 16 - 18)]
\]

\[
= 10^{-9} \left[30\hat{i} + 21\hat{j} - 2\hat{k}
\right]
\]
18. In YDSE wavelength of light used is 500 nm and slit width is 0.05 mm. then the angular fringe width will be

(1) 1.8°  (2) 3.2°  (3) 0.57°  (4) 0.48°

Ans.  (3)

Sol. \[ \beta_0 = \frac{\lambda}{d} = \frac{500 \times 10^{-9}}{5 \times 10^{-5}} = 10^{-2} \text{ Radian} = 0.57° \]

19. A radioactive sample remains undecayed after time \( \frac{t}{2} \). How much sample remains undecayed after

(1) \( \frac{3}{4} \)  (2) \( \frac{9}{16} \)  (3) \( \frac{4}{3} \)  (4) \( \frac{16}{9} \)

Ans.  (1)

Sol. \[ N = N_0 e^{-\lambda t} \quad \ldots(1) \]

\[ N' = N_0 e^{-\frac{\lambda}{2} t} \quad \ldots(2) \]

from (1) & (2)

\[ \left( \frac{N'}{N_0} \right) = \left( \frac{N}{N_0} \right)^{\frac{1}{2}} = \left( \frac{9}{16} \right)^{\frac{1}{2}} = \frac{3}{4} \]

20. Electromagnetic wave is given by \( B = 3 \times 10^{-8} \sin(ky + \omega t) \hat{i} \) find \( E = ? \)

(1) \( 9 \sin(ky + \omega t) \) \( \hat{\imath} \) v/m  (2) \( 9 \sin(ky + \omega t) \) \( \hat{k} \) v/m

(3) \( 6 \sin(ky + \omega t) \) \( \hat{k} \) v/m  (4) \( 4 \sin(ky + \omega t) \) \( \hat{\imath} \) v/m

Ans.  (1)

Sol. \( E_0 = cB_0 \)

\[ E = 3 \times 10^8 \times 3 \times 10^{-8} \sin(ky + \omega t) \hat{k} = 9 \sin(ky + \omega t) \hat{k} \]
21. Given a volume of solid cylinder, find the ratio \( \frac{\ell}{R} \) such that moment of inertia of cylinder about axis Oo' will be maximum figure.

\( \begin{align*}
(1) & \sqrt{\frac{3}{2}} \\
(2) & \sqrt{2} \\
(3) & \frac{2}{\sqrt{3}} \\
(4) & \frac{1}{\sqrt{2}}
\end{align*} \)

Ans. (1)

Sol. Let a cylinder of mass \( m \) length \( L \) and sodium \( R \) then let take elementary disc of sodium \( R \) and thickness \( dx \) at a distance of \( x \) from axis Oo' then moment of inertia about Oo' as this element

\[
\begin{align*}
\text{dl} &= \frac{dmR^2}{4} + dx^2 \\
I &= \int \text{dl} = \int \frac{dmR^2}{4} + \int_{n=L/2}^{n=L} \frac{M dx}{L} x^2 \\
I &= \frac{MR^2}{4} + \frac{ML^2}{12} \\
I &= \frac{M}{4L^2 \pi} + \frac{ML^2}{12} \\
I &= \frac{M}{4\pi} + \frac{ML^2}{12} \\
\frac{\text{dl}}{\text{dL}} &= \frac{-mV}{4\pi^2 L^2} + \frac{M \times 2L}{12} = 0 \\
\Rightarrow & \quad V = \frac{2}{3} \pi L^3 \\
\Rightarrow & \quad \pi R^2 L = \frac{2}{3} \pi L^3 \\
\Rightarrow & \quad \frac{L}{R} = \sqrt{\frac{3}{2}}
\end{align*}
\]
22. Energy of electron in its nth orbit is given as $E_n = \frac{-13.6}{n^2} \times z \ eV$. Consider a hydrogen atom, find the amount of energy needed to transfer electron from 1st orbit to 3rd orbit:

(1) 13.6 eV  (2) 1.51 eV  (3) 3.4 eV  (4) 12.09 eV

Ans. (4)

Sol. For hydrogen, $Z = 1$

Energy of 1st orbit $E_1 = \frac{-13.6}{12} \ eV = -13.6 eV$

Energy of 3rd orbit $E_3 = \frac{-13.6}{12} \ eV = -1.51 eV$

Energy difference $DE = E_3 - E_1 = 12.08 eV$

23. An external pressure $P$ is applied on a cube at 273 K T hence it compresses equally from all sides, $\alpha$ is the coefficient of linear expansion & $K$ is the bulk modulus of material. To bring the cube to its original size by heating, the temperature rise must be

(1) $\frac{P}{3\alpha K}$  (2) $\frac{P}{\alpha K}$  (3) $\frac{P}{2\alpha K}$  (4) $\frac{P}{4\alpha K}$

Ans. (1)

Sol. $K = -\frac{P}{\Delta V / V} \Rightarrow \left(\frac{\Delta V}{V}\right)_1 = -\frac{P}{K}$

& due to thermal expansion

$\left(\frac{\Delta V}{V}\right)_2 = \gamma \Delta \theta$ [where $\Delta \theta$ is increase in temp]

Also, ($\gamma = 3\alpha$)

$\Rightarrow \left(\frac{\Delta V}{V}\right)_1 + \left(\frac{\Delta V}{V}\right)_2 = 0$ [for restoring shape]

$\Rightarrow \frac{P}{K} + 3\alpha \Delta \theta = 0$

$\Delta \theta = \frac{P}{3\alpha K}$
24. In the series LCR circuit as shown in figure, due to the heat developed in t seconds temperature of resistance increases by 10°C. If heat capacity of resistance material is 100 J/°C. Then calculate the value of t.

In श्रेणीक्रम LCR परिपथ में t सेकंड में उत्पन्न ऊर्जा के कारण प्रतिरोध का ताप 10°C से बढ़ जाता है यदि प्रतिरोध के पदार्थ की ऊर्जाधारिता 100 J/°C हो तो t का मान ज्ञात कीजिये।

\[ E = 25 \sin (100\pi nt + \pi/2) \]

(1) 10 second  (2) 20 second  (3) 30 second  (4) 40 second

**Ans.**
(2)

**Sol.**
Heat ऊर्जा = \( (i_{rms})^2 \cdot R \)

\[ i_{rms} = \frac{25}{Z\sqrt{2}} \] where \( Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{4^2 + (7 - 4)^2} = 5 \Omega \)

\[ \Rightarrow \text{Heat} = \left( \frac{25}{5\sqrt{2}} \right)^2 \times 4 \times t = m \Delta \theta = 100 \times 10 \] and Amplitude of wattless current = \( i_0 \sin \phi \)

\[ t = 20 \text{ second} \]

25. A body is shown vertically upwards. Which graph represents the variation of velocity wrt time?

(1)  (2)  (3)  (4)

**Ans.**
(3)

**Sol.**
Using 1st equation of motion
Initial velocity = \( u \)
acceleration = \( -g \)

\[ v = u + at \Rightarrow v = u - gt \] ...(1)
Equation (1) represents a straight line curve with (–ve) slope. Hence answer is (3)