PART: PHYSICS

1. In Atwood machine if $m_2 = 2m_1$ then acceleration of both mass is $a_1$. However when $m_2 = 3m_1$ then acceleration of both mass is $a_2$. Find $a_1/a_2$. 
2. Find radius of gyration about an axis passing through mid-point of thin rod (L = 10\sqrt{3} m)

\[ L = 10\sqrt{3} \]

(1) 2 m
(2) 3 m
(3) 5 m
(4) 8 m

Ans. (3)

Sol. \[ i = \frac{m_1^2}{12} - mk^2 \]
\[ \Rightarrow k^2 = \frac{\sqrt{2}}{12} \Rightarrow k = \frac{i}{\sqrt{12}} = \frac{10\sqrt{3}}{\sqrt{12}} = \frac{10\sqrt{3}}{2\sqrt{3}} = 5 \]

3. Two particles are projected with same speed \( u \) but different angles of projection 45° and 30° respectively, then ratio of range is:

(1) \( \frac{2}{\sqrt{3}} \)
(2) \( \frac{1}{2} \)
(3) \( \frac{1}{\sqrt{3}} \)
(4) \( \sqrt{3} \)

Ans. (1)

Sol. \[ R = \frac{u^2 \sin \theta}{g} \]
4. \( n \) is degree of freedom of gas, then ratio of \( \frac{C_v}{C_p} = ? \)

(1) \( 1 - \frac{2}{n} \)
(2) \( \frac{n}{n+2} \)
(3) \( \frac{n}{2} \)
(4) \( 2n \)

Ans. \( 2 \)

Sol. \( 1 - \frac{2}{n} \)

5. A nucleus of mass \( m \) disintegrate into two pieces of mass \( \frac{m}{3} \) and \( \frac{2m}{3} \). The ratios of their de-Broglie wavelength will be:

(1) \( \lambda_1 : \lambda_2 = 1 : 2 \)
(2) \( \lambda_1 : \lambda_2 = 2 : 1 \)
(3) \( \lambda_1 : \lambda_2 = 1 : 1 \)
(4) \( \lambda_1 : \lambda_2 = 4 : 3 \)

Ans. \( 3 \)

Sol. Since their momentum will be same, so \( \lambda_1 = \lambda_2 \)

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8. An n-p-n transistor in common emitter mode is used as an amplifier \( R_{\text{in}} = 0.5 \text{ k}\Omega \) and \( R_{\text{out}} = 2\text{k}\Omega \). The graph of \( i_c \) vs \( i_e \) is as shown in the diagram:

The voltage gain for the transistor will be:

(1) 100
(2) 200
(3) 400
(4) 50

Ans. (2)

Sol. \( \beta_{\text{AC}} = \frac{\Delta i_c}{\Delta i_e} = \frac{(10-5) \times 10^{-3}}{(200-100) \times 10^{-3}} = 50 \)

\( A_v = \frac{R_{\text{out}}}{R_{\text{in}}} = 50 \times \frac{2}{0.5} = 200 \)

9. A ball of mass \( m = 0.15 \text{ kg} \) moving with speed \( 12 \text{ m/s} \) collide elastically perpendicular with wall and rebound with same speed, if force applied by wall is \( 100 \text{ N} \). Then time of collision is:

(1) 0.025 sec
(2) 0.036 sec
(3) 0.005 sec
(4) 0.018 sec

Ans. (2)

Sol. \( F = \Delta P = \frac{2m\Delta v}{\Delta t} \)

\( \Delta t = \frac{2m\Delta v}{F} = \frac{2 \times 0.15 \times 12}{100} = 0.036 \text{ sec} \)

10. A particle is projected with velocity one third of escape velocity at earth surface from earth in direction perpendicular to surface of earth. Determine the maximum height above earth surface upto which it can reach. (Take radius of earth = 6400 km)

(1) 1600 km
(2) 700 km
(3) 800 km
(4) 1000 km

Ans. (3)

Sol. \( V = \frac{V_e}{3} \)
11. One main scale division of a vernier callipers represents 1 mm and 10 vernier scale divisions matching with 9 main scale divisions. Zero error of the vernier is −0.4 mm. If a sphere is fitted between the jaws, the zero of vernier scale lies between 30th and 31st mark of main scale and 6th vernier scale mark matches with some main scale mark. The diameter of the sphere will be:

(1) 3.02 cm  (2) 3.10 cm  (3) 3.06 cm  (4) 3.08 cm

Ans. (2)

Sol.

10 VSD \[ \text{9 MSD} = 9 \text{mm} \]

1 VSD \[ \text{9 mm} = 0.9 \text{ mm} \]

L.C. = 1 MSD − 1 VSD = 1 mm − 0.9 mm = 0.1 mm

Zero error = −0.4 mm

Measured diameter = main scale reading + (Vernier scale reading (Least count))

= 30 mm + (0.1 mm) = 30.6 mm

Actual diameter = (measured diameter) − Zero error

= (30.6 mm) − (−0.4 mm) = 31.0 mm = 3.10 cm

12. In the circuit containing two capacitor and battery as shown in figure. Initially switch was closed, then energy of system is E₁. Now switch is opened and dielectric of K = 5 is inserted between the plate of both capacitor. Energy of system is E₂. If C₁ = C₂ = C. Determine ratio E₁ : E₂:

![Diagram of two capacitors and battery](Image)

(1) 1 : 13  (2) 2 : 13  (3) 5 : 13  (4) 3 : 5

Ans. (3)

Sol. Case-1: Switch has closed C_{eq} = C_1 + C_2 = 2C

Energy = E₁ = \frac{1}{2} C_{eq} V^2 = \frac{1}{2} 2C V^2 = CV^2

Case-2: Switch is opened and dielectric of K = 5 is inserted between the plate of both capacitor

Energy = E₂ = \frac{1}{2} K C V^2 = \frac{1}{2} 5C V^2 = 2.5CV^2

Ratio E₁ : E₂ = CV^2 : 2.5CV^2 = 1 : 2.5

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Case-2: Now switch is opened and dielectric of \( K = 5 \) is filled in both capacitor.
Charge on \( C_1 \) before closing of switch = \( CV \) on opening of switch \( C_1 \) become isolated so charge on \( C_1 \) remain same i.e. \( CV \)

\[ E_2 = \frac{(CV)^2}{2 	imes 5C} = \frac{1}{2} \times 5C \times V^2 \]

\[ \Rightarrow CV^2 = \frac{1}{10} \times \frac{5}{2} \]

\[ \Rightarrow CV^2 = \frac{2}{10} + \frac{25}{10} \]

\[ CV^2 = \frac{26}{10} = \frac{13}{5} CV^2 \]

Ratio \( E_1 : E_2 = \frac{CV^2}{12} \times \frac{5}{13} \)

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13. In a medium speed of light is \( 1.5 \times 10^8 \) m/s and in another medium speed of light is \( 2 \times 10^8 \) m/s. Find critical angle for given two media.

   \[ \begin{align*}
   (1) \quad & \sin \frac{3}{4} \\
   (2) \quad & \sin \frac{3}{5} \\
   (3) \quad & \sin \frac{1}{4} \\
   (4) \quad & \sin \frac{1}{3}
   \end{align*} \]

   Ans. (1)

Sol. \( \sin \theta = \frac{V_1}{V_2} = \frac{1.5 \times 10^8}{2 \times 10^8} = \frac{1.5}{2} \)

\[ \Rightarrow \sin \theta = \frac{3}{4} \Rightarrow \theta = \sin^{-1} \frac{3}{4} \]

Ans.

14. Find value of \( n \) as shown in figure

\[ \begin{align*}
(1) \quad & n = \sqrt{\frac{27}{4}} \\
(2) \quad & n = \frac{4}{3} \\
(3) \quad & n = \frac{4\sqrt{3}}{3} \\
(4) \quad & n = \frac{5\sqrt{3}}{4}
\end{align*} \]

Ans. (1)
15. There are two vectors $\vec{A} = 2\hat{i} - 3\hat{j} - \hat{k}$ and $\vec{B} = \hat{i} - 2\hat{j} + 2\hat{k}$. Determine magnitude of components of $\vec{A}$ vector along $\vec{B}$.

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

Ans.  (3)

Sol.

\[
\text{Component} = \vec{A} \cos \theta
\]

\[
\text{where } \cos \theta = \frac{\vec{A} \cdot \vec{B}}{\|\vec{A}\| \|\vec{B}\|}
\]

\[
\begin{align*}
\vec{A} \cdot \vec{B} &= 2 \times 1 + (-3) \times (-2) + (-1) \times 2 \\
&= 2 + 6 - 2 \\
&= 6
\end{align*}
\]

\[
\|\vec{B}\| = \sqrt{1 + 4 + 4} = 3
\]

\[
\text{Component} = \frac{6}{3} = 2
\]

16. In case-I time period of oscillations of block is $3$ second, if time period of block is $\sqrt{x}$ in case-II then find value of $x$.

(1) 2  (2) 4  (3) 6  (4) 8

Ans.  (1)

Sol.

In case-I $k_{eq} = \frac{2k}{2k + \frac{2k}{3}} = \frac{3k}{3}$

In case-II $k_{eq} = k + 2k = 3k$

In case-I $T = 3 = \frac{m}{2k} \Rightarrow \sqrt{\frac{3m}{2k}}$

In case-II $T = \sqrt{\frac{m}{3k}} \Rightarrow \sqrt{\frac{m}{2k}}$
17. Two concentric loops of radii 30 cm and 50 cm carrying equal currents \( i = 7 \) A in opposite directions are kept in x-y plane as shown in figure find net magnetic moment of the system.

\[
\begin{align*}
(1) & : 7k \\
(2) & : -\frac{7}{2}k \\
(3) & : \frac{7}{2}k \\
(4) & : 7k
\end{align*}
\]

Ans. (2)

Sol. Net magnetic moment

\[
M = \ln(\frac{50}{30})^2 - \ln(\frac{50}{30})^2 = \frac{4 \pi 7}{25} + \frac{4 \pi 7}{25} = \frac{7}{2}\]

18. Binding energy per unit nucleon of nucleus \( X^2 \) and \( Y^2 \), are respectively 1.1 Mev and 7.6 Mev. If two nuclei of \( X^2 \) combine to form a nucleus of \( Y^2 \), then find the mass loss in amu:

\[
\begin{align*}
(1) & : 0.014 \\
(2) & : 0.018 \\
(3) & : 0.039 \\
(4) & : 0.028
\end{align*}
\]

Ans. (4)

Sol. BE\(_1\) = (1.1 MeV) \times 2 \times 2 = 4.4 MeV

BE\(_2\) = (7.6 MeV) \times 4 = 30.4 MeV

Energy released = (-4.4 MeV) – (-30.4 MeV)

= 26 MeV = (931) \text{ amu}

\[
\Delta m = \frac{26}{931} = 0.028 \text{ amu}
\]

19. Magnetic flux passing through a coil of resistance \( R \) is given by \( \phi = \frac{2}{3} (9 - i) \). Find total heat dissipated in Joule till the flux becomes zero.

\[
\begin{align*}
(1) & : 2 \\
(2) & : 4 \\
(3) & : 5 \\
(4) & : 6
\end{align*}
\]

Ans. (1)
Sol. \( \delta = \frac{2}{3} (9 - 6) = 0 \) \Rightarrow t = 3 \text{sec.}

Induced EMF in coil is \( e = -\frac{\Delta \phi}{\Delta t} \)

\( \Rightarrow e = \frac{2}{3} (0 - 2t) \)
\( \Rightarrow e = \frac{4t}{3} \)

Now Heat produced \( H = \int \frac{e^2}{R} dt \)

\( \Rightarrow H = \frac{16}{9 \times 8} \int_{0}^{2} t^2 dt = \frac{16}{9 \times 8} \times \frac{1}{3} \times 27 = 2 \text{Joule} \)

20. Equation of a linear wave is \( y = 2 \sin (\pi x - kx) \) cm if it is given that maximum velocity of particle is equal to wave velocity. Find wavelength in cm

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

Ans. \( (1) \)

Sol. According to questions

\( v_{\text{max}} = v_0 \Rightarrow \text{Ans} = \frac{v_0}{k} \)

\( \Rightarrow \frac{2}{\lambda} = \frac{v_0}{k} \Rightarrow k = \frac{\lambda}{2} \)

\( \Rightarrow 2 \pi / \lambda = 1 / 2 \)

\( \Rightarrow \lambda = 4 \pi \)

21.

\[ \begin{array}{c}
\text{4 volt} \\
780 \Omega \\
20 \text{mV}
\end{array} \]

If length of the potentiometer wire is 300 cm and the balance length is found to be 60 cm for 20 mV cell, then find the total resistance of the potentiometer wire.

\( \begin{align*}
(1) & \ 40 \ \Omega \\
(2) & \ 20 \ \Omega \\
(3) & \ 60 \ \Omega \\
(4) & \ 80 \ \Omega
\end{align*} \)

Ans. \( (2) \)

Sol. \( \frac{\text{4}}{780 + R} \times \frac{R}{300} \times 60 - 20 \times 10^{-3} \)

\( R = 20 \)

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23. A cuboid ice piece of dimension 60 cm × 50 cm × 20 cm is packed inside a copper cover of thickness 1 cm. Thermal resistivity of copper is 0.05 m·K/watt, the temperature of the outer surface of copper is 40°C and Lf for ice is 3.4 × 10⁶ J/kg, then the rate of ice melting will be:

(1) 0.14 Kg/sec. (2) 0.24 Kg/sec. (3) 0.35 Kg/sec. (4) 0.47 Kg/sec.

Ans. (2)
Sol.

\[
\text{Area} = 2((0.6 \times 0.5) + (0.5 \times 0.2) + (0.2 \times 0.6))
\]

\[
\text{Area} = 1.04 \text{m}^2
\]

\[
\text{Thermal resistance of Cu layer} = \frac{\alpha}{A} = \frac{0.05 (1 \times 10^{-2})}{1.04} = 5 \times 10^{-4}
\]

\[
I_n = \frac{\Delta T}{R_{th}} = \frac{40 - 0}{5 \times 10^{-4}} = 8 \times 10^4 \text{ J/sec} = \frac{dQ}{dt}
\]

\[
\frac{dQ}{dt} = \frac{dQ}{dt} = \left(\frac{dQ}{dt}\right)_{L_i} = 8 \times 10^4 \times \frac{3.4 \times 10^5}{3.4 \times 10^5} = 0.24 \text{ kg/sec.}
\]

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24. Two conducting hollow spheres of radius 5 mm and 10 mm respectively are placed such that their center to center distance is 20 cm. If they are connected by a conducting wire, then the ratio of electric field just outside the surface will be:

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

Ans. (2)
Sol.

\[
E_1 = E_2 = \frac{kQ}{R^2}
\]

\[
\text{Potential} = \frac{kQ}{R}
\]

\[
E = \frac{kQ}{R^2} = \frac{kQ}{R} \cdot \frac{\text{constant}}{R}
\]

\[
\frac{E_1}{E_2} = \frac{R_2}{R_1} = \frac{10}{5} = 2.
\]
Scholarship upto 100% on the basis of JEE (Main) Percentile Score

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