PART: PHYSICS

1. A body of mass 2 kg and linear velocity 4 m/s collides elastically head on with another body at rest. After collision body of mass 2 kg starts moving with velocity 1 m/s then what will be the velocity of center of mass of system?
   (1) 1.5 m/s  (2) 0.5 m/s  (3) 3.5 m/s  (4) 2.5 m/s

   Ans. (4)

   Sol. From linear momentum conservation
   \[ 2 \times 4 + 0 = 2 \times v \]
   \[ 2v = 8 \]
   \[ v = 4 \text{ m/s} \]

   From the definition of elastic collision
   \[ v_f = v_i - \frac{m_1}{m_1 + m_2} v \]
   \[ v_f = 1 - \frac{2}{2+2} \times 4 \]
   \[ v_f = -2.5 \text{ m/s} \]
What will be the speed of pendulum mass, when string of pendulum makes an angle of 60° with vertical?

\[ v_c = 1 \left( 4 - 0 \right) \]
\[ v_c = 5 \]
\[ \beta = 2 + m_u \times 5 \]
\[ m_u = 5 \times 5 \]

\[ v_{cm} = \frac{m_1 v_{1} + m_2 v_{2}}{m_1 + m_2} = \frac{2 \times 4 + 0}{2 \times 4 + 0} \]
\[ = \frac{2 \times 4}{4} = \frac{2.5 m/s}{2} \]

Answ. (1)

Sol. \[
\begin{align*}
\frac{1}{2} m_2 \dot{v}^2 &= \frac{1}{2} m_2 v^2 + mg \left( 1 - \cos 60° \right) \\
\dot{v}^2 &= v^2 + 2g \left( 1 - \cos 60° \right) \\
v &= 5 + 10 \times \frac{1}{2} \times 1 \frac{1}{2} \\
v &= 5 + 5 \\
 &= 10 m/s
\end{align*}
\]
4. Two geometrical identical wires have young modules \( Y_1 \) and \( Y_2 \), then find equivalent young modules:

\[
\begin{align*}
(1) & \quad Y_1 + Y_2 \\
(2) & \quad \frac{Y_1 + Y_2}{2} \\
(3) & \quad \frac{Y_1 Y_2}{Y_1 - Y_2} \\
(4) & \quad \sqrt{Y_1 Y_2}
\end{align*}
\]

Ans. \( (2) \)

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5. Battery is connected to a resistor and a inductor for a long time as shown in figure, then battery is removed & short circuited. Find the current in the circuit after \( 1 \) ms after battery get removed:

\[
\begin{align*}
R & = 10 \Omega \\
L & = 10 \text{mH}
\end{align*}
\]

\[
\begin{align*}
\text{Ans.} \quad (4)\quad 0.74A
\end{align*}
\]

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6. A particle of mass \( 4m \) at rest splits into two particle of mass \( 3m \) and \( m \). If both the masses have different velocities then find ratio of their De-Broglie wavelength?

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

Ans. \( (3) \)

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7. An electron, a proton and an alpha particle are get accelerated by giving same K.E., then which of the following is correct about De-Broglie wavelength.

\[
\begin{align*}
(1) & \quad \lambda_e < \lambda_p < \lambda_{\alpha} \\
(2) & \quad \lambda_e > \lambda_p > \lambda_{\alpha} \\
(3) & \quad \lambda_e = \lambda_p < \lambda_{\alpha} \\
(4) & \quad \lambda_e = \lambda_p > \lambda_{\alpha}
\end{align*}
\]

Ans. \( (2) \)
8. A ball of mass $m$ is thrown towards a wall in two different situations,
(i) Ball strikes perpendicular to wall
(ii) Ball strikes at an angle of $45^\circ$ to wall
What will be ratio of impulse in two cases?

Ans. (2)

Sol.

During elastic collision with vertical wall, velocity in vertical direction remains constant and component velocity along horizontal direction become opposite after collision.
So, change in momentum,

$$\Delta p = m \Delta v$$

9. Photons of wavelength 400nm strikes on a material with energy 1000J in 10 sec. What will be no. of electron leaving the material in one second?

(i) $5 \times 10^9$
(ii) $5 \times 10^{10}$
(iii) $5 \times 10^{11}$
(iv) $5 \times 10^{12}$

Ans. (2)

Sol.

Energy $= N \times \frac{h\nu}{\lambda}$

$$1000 = \frac{12400}{400} \times N \times 1.6 \times 10^{-19}$$

$$N = \frac{1000 \times 4}{12400 \times 1.6 \times 10^{-19}}$$

So, number of electron leaving from material in 1 sec $= \frac{N}{10} = 5 \times 10^{10}$

10. A radioactive nuclei of initial number of active nuclei $N_0$. Decays to active nuclei in time $t_1$ and decays to no active nuclei in time $t_2$. Find the ratio between $t_1$ and $t_2$?

Sol.

$$N = N_0 e^{-\frac{t}{\lambda}}$$

$$t_1 = \frac{n_1}{\lambda}$$

$$t_2 = \frac{n_2}{\lambda}$$

$$\frac{t_1}{t_2} = \frac{2 n_2 - n_1}{n_2} = 2 - 1.098 = 0.902 = 0.42$$
11. For an ideal gas, \( C_v \) is the specific heat at constant volume and \( C_p \) is the specific heat at constant pressure. If at some temperature \( T_0 \), they are related as \( C_v - C_p = R \) and for some other temperature \( T_0 \) they are related as \( C_v - C_p = 1 \cdot 1R \), then which is correct?

(1) \( T_2 > T_1 \)
(2) \( T_0 > T_2 \)
(3) \( T_1 = T_0 \)
(4) can't say

Ans. (1)

Sol. At high temperature gas behaves as ideal gas.

12. Find equivalent circuit.

![Diagram of a circuit](image)

(1) NOR
(2) OR
(3) AND
(4) NAND

Ans. (3)

Sol.

13. Two blocks of mass 800 gm and 200 gm are attached by two springs of spring constant 4 k and k in series as shown in figure. Find angular frequency of oscillation of system? (Value of k = 20 N/m)

![Diagram of a block and springs](image)

Ans. (1)

Sol.

\[ T = 2\pi \sqrt{\frac{m}{\sum k}} \]

\[ \mu = \frac{m_1 \cdot m_2}{m_1 + m_2} = \frac{200 \times 800}{200 + 800} = 160 \, \text{kg} \]

\[ k_{eq} = k_1 \cdot k_2 \]

\[ k_{eq} = \frac{4 \cdot k}{5} = \frac{4 \cdot 20}{5} = 16 \, \text{N/m} \]

\[ T = 2\pi \sqrt{\frac{16}{16}} \]

\[ T = 2\pi \sqrt{1} = \pi \, \text{sec} \]

\[ m = 2 \, \text{rad/s} \]
15. An electric field of a wave propagating as \( E = E_0 \cos(kz - 5.6 \times 10^5 t) \) reflecting from mirror at \( z = a \), then

1. \( \lambda = 5.6 \ m \)
2. \( f = 5.6 \times 10^5 \) Hz
3. Equation of reflected wave \( E = E_0 \cos(kz - 5.6 \times 10^5 t) \)
4. Equation of reflected wave \( E = E_0 \cos(kz + 5.6 \times 10^5 t) \)

\( \text{Ans.} (4) \)

\( \text{Sol.} \)
\[
\begin{align*}
\lambda &= 5.6 \times 10^5 \\
2\pi &= \frac{5.6 \times 10^5}{2 \times 5.6 \times 10^3} = 891.7 \text{Hz} \\
C &= 3 \times 10^8 \\
\lambda &= \frac{c}{f} = \frac{3 \times 10^8}{891.7} \\
\text{Reflecting wave} \\
F &= F_0 \cos(kz - 891.7) \\
\end{align*}
\]

16. Two similar charge of magnitude \( q \) are fixed at distance of 2m. And another opposite charge of same magnitude is brought at center point between two charges and given a slight displacement along equatorial direction and released then angular frequency of oscillations of opposite charge will be? (Value of \( q^2 = 10 \) C^2) (Mass of opposite charge 0.2 gram)

1. \( 3 \times 10^2 \) rad/s
2. \( 3 \times 10^5 \) rad/s
3. \( 3 \times 10^{-3} \) rad/s
4. \( 3 \times 10^6 \) rad/s

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

\( \text{Sol.} \)

\[ q \]
\[ 2m \]
\[ q \]

17. Water drops are falling from a tap in regular interval of time. A drop falls from the tap and after 4 second of falling the drop is 34.3m away from next drop. Then drops are falling at rate of (Use \( g = 9.8 \ m/s^2 \))

1. 1 drop in 1 sec
2. 1 drop in 7 sec
3. 1 drop in 5 sec
4. 1 drop in 6 sec

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

\( \text{Sol.} \)

Let next drop after 1 sec distance travelled by \( F \) drop in 4 sec is \( S_F = \frac{1}{2} at^2 = 78.4 \ m \) (it should be less than 4 sec) distance travelled by succeeding drop in \( 4 - t \) sec

\[ S_F = \frac{1}{2} a (4 - t)^2 \]
18. In YDSE, distance between the slits are varied as \( d = a + b \sin \omega t \). What will be the difference between maximum and minimum fringe width?

\[
\begin{align*}
(1) \quad & \frac{2bD_2}{a^2-b^2} \\
(2) \quad & \frac{4bD_2}{a^2-b^2} \\
(3) \quad & \frac{3bD_2}{a^2+b^2} \\
(4) \quad & \frac{5bD_2}{a^2+b^2}
\end{align*}
\]

Ans. (1)

Sol. Fringe width = \( \frac{D_1}{d} \)

\[ \beta = \frac{D_2}{(a+b) \sin \omega t} \]

\[ \beta_{\text{max}} - \beta_{\text{min}} = \frac{D_1}{a-b} - \frac{D_1}{a+b} = D_1 \left( \frac{a+b}{a^2-b^2} \right) = \frac{2bD_1}{a^2-b^2} \]

19. Match the following column.

\[
\begin{align*}
(i) & \overset{\downarrow}{A} & (a) & \overset{\downarrow}{C - A - B} = 0 \\
(ii) & \overset{\downarrow}{A} & (b) & \overset{\downarrow}{A - C - B} = 0 \\
(iii) & \overset{\downarrow}{A} & (c) & \overset{\downarrow}{B - A - C} = 0 \\
(iv) & \overset{\downarrow}{C} & (d) & \overset{\downarrow}{A + B - C} = 0 \\
(1) & (i) & (ii) & (iii) & (iv) \\
(2) & (i) & (ii) & (iii) & (iv) \\
(3) & (i) & (ii) & (iii) & (iv) \\
(4) & (i) & (ii) & (iii) & (iv)
\end{align*}
\]

20. In a parallel plate capacitor distance between the plates is \( 'd' \). If dielectric of variable permeability is filled as :

\[
\begin{align*}
c(x) &= c_0 + kx & : 0 < x < \frac{d}{2} \\
c(x) &= c_0 + k(d - x) & : \frac{d}{2} < x < d
\end{align*}
\]

Find capacitance?

\[
\begin{align*}
(1) \quad & \frac{1}{A_k} \times \frac{e_0}{2} \\
(2) \quad & \frac{1}{A_k} \times \frac{e_0 + kd}{2} \\
(3) \quad & \frac{1}{A_k} \times \frac{e_0}{2} \\
(4) \quad & \frac{1}{A_k} \times \frac{e_0 + kd}{2}
\end{align*}
\]

Ans. (2)
21. The position of an object varies as \( \mathbf{\mathbf{R}} = 10\mathbf{a}(t^2 + 5t)(t - 5) \). Find the time at which its momentum is zero.

**Ans.**

(1) 10 sec
(2) 12 sec
(3) 15 sec
(4) 17 sec

**Sol.**

\[
\mathbf{\mathbf{R}} = 10\mathbf{a}(t^2 + 5t)(t - 5)
\]

\[\mathbf{v} = 20\mathbf{a}(t + 5)\mathbf{i}\]

\[\mathbf{L} = \mathbf{m}\mathbf{v} \times \mathbf{L}
\]

at \( t = 0 \), \( \mathbf{L} = 0 \)

At any time \( t \)

\[\mathbf{L} = \mathbf{m}(20\mathbf{a}(t + 5)(t - 5)) \times (20\mathbf{a}(t + 5)\mathbf{i})
\]

\[\mathbf{L} = 0 \Rightarrow 100\mathbf{a}^2(t^2 - 5)\mathbf{k} = 0
\]

\[t^2 - 5 = 0 \Rightarrow t = \pm 5\]

\[10^2 - 5 = 0 \Rightarrow t = 15 \text{ sec}
\]
22. A message signal \( v_m = 10 \sin \left( 2\pi \times 10^9 \right) \) is amplitude modulated with carrier signal \( v_c = 20 \sin \left( 2\pi \times 10^9 \right) \); then find the half of bandwidth.

Sol. Bandwidth \( = 2f_m \)

\[ \text{Half of bandwidth} = f_m \]

\[ = 10^9 \text{ Hz} \]

\[ = 100 \text{ KHz} \]

23. Circuit shown is in the balanced state in which galvanometer shows non deflection. Given that wire AB has 0.01 \( \Omega \) cm of resistance. Find maximum possible value of voltage that can be measured by this set up.

Ans. (2)

Sol. At zero deflection

\[ V_{ea} = \frac{20}{10 + 6} = 12.5V \]
25. For a magnetic material, the relative change in magnetic susceptibility is equal to $2.2 \times 10^{-4}$. Find the percentage change in magnetic field.

**Ans.**

(1) 0.012  
(2) 0.025  
(3) 0.022  
(4) 0.028

**Sol.**

$\mu = 1 + \chi$

$\Delta \mu = \Delta \chi$

$B = k \mu$

$\% \text{ change} = \frac{\Delta B}{B} \times 100$

$= \frac{2.2 \times 10^{-4}}{B} \times 100$

$= 0.022 \%$

26. A ray of light is incident on the boundary of an equilateral triangle ABC. The angles of incidence and reflection are $60^\circ$ and $30^\circ$ respectively. The angle of refraction is $22^\circ$. The diagram of following is correct (given $\alpha = 2.42$)

(1) The incident of ray will not get refracted  
(2) The ray will not get refracted if incident at $60^\circ$  
(3) The ray will get refracted if incident at $22^\circ$  
(4) There is always TIR for angle greater than $30^\circ$

27. A monatomic gas filled in a piston cylinder arrangement; its temperature changes from $T_1$ to $T_2$ and length of gas column changes from $L_1$ to $L_2$. Against atmosphere. Then the ratio of $T_1/T_2$:

(1) $\frac{L_1}{L_2}$  
(2) $\frac{L_1}{L_2}$  
(3) $\frac{L_1}{L_2}$  
(4) $\frac{L_1}{L_2}$

at constant atmospheric pressure

$T_1 = \frac{V_1}{V_2}$

$T_2 = \frac{V_1}{V_2}$

$T_1 = \frac{V_1}{V_2}$

$T_2 = \frac{V_1}{V_2}$

$T_1 = \frac{V_1}{V_2}$
28. A particle is revolving around a planet with maximum distance \( x \) and minimum distance \( y \). If maximum velocity of particle is \( v_0 \), then find minimum velocity of particle:

\[
\begin{align*}
(1) & \quad \frac{v_0 x}{y} \\
(2) & \quad \frac{v_0 y}{x} \\
(3) & \quad \frac{v_0 x^2}{y^2} \\
(4) & \quad \frac{v_0 y^2}{x^2}
\end{align*}
\]

Ans. (2)

Sol. By angular momentum conservation

\[
v_y = \frac{mv_0 y}{x}
\]

29. A radioactive material of mass number 158 decays with half-life of 3 days. If initial amount of radioactive material is 2 mg, then its initial activity will be:

\[
\begin{align*}
(1) & \quad 1625 \times 10^9 \text{ dps} \\
(2) & \quad 1625 \times 10^3 \text{ dps} \\
(3) & \quad 1625 \times 10^6 \text{ dps} \\
(4) & \quad 1625 \times 10^9 \text{ dps}
\end{align*}
\]

Ans. (2)

Sol. No. of nuclei = \( \frac{m}{M} \times \frac{2 \times 10^3}{198} \times 6.02 \times 10^{23} \)

Activity = \( \frac{N_0}{3 + 24 \times 60 \times 60} \times \frac{2 \times 10^3}{198} \times 6.02 \times 10^{23} \)

\[
1625 \times 10^9 \text{ dps}
\]

30. Based on given statement choose the correct option

Statement 1: For a disc situated in x-y plane. The radius of gyration is same for x-axis, y-axis and z-axis.

Statement 2: In case of rigid body motion there is no change in shape and mass.

(1) Statement 1 & 2 both are true

(2) Statement 1 is true, Statement 2 is false

(3) Statement 1 is false, Statement 2 is true

(4) Statement 2 is true, Statement 1 is false

Ans. (3)