PHYSICS

1. A bullet of mass 10 grams is moving with horizontal velocity \( v \), hits the ball placed on the tower of height 20 m from ground. After collision, bullet hits the ground 120 m and ball hits the ground 30 m from the foot of tower. Find velocity \( v \) (in m/sec).

   Ans. 360

   Sol. \( t = \sqrt{\frac{2 \times h}{g}} = \sqrt{\frac{2 \times 20}{10}} = 2 \text{ sec} \)

   for 200 grams
   
   30 = \( v_2 \times 2 \)
   
   \( v_2 = 15 \text{ m/s} \)

   for 10 gm
   
   120 = \( v_1 \times 2 \)
   
   \( v_1 = 60 \text{ m/s} \)

   Using linear momentum conservation
   
   \( 10 \times v = 200 \times 15 + 10 \times 60 \)
   
   \( v = 360 \text{ m/s} \)

2. For a polytropic process \( P T^n = \text{constant} \) where \( P \) is pressure and \( T \) is temperature. Find coefficient of volume expansion.

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

   Ans. (3)

   Sol. \( P T^n = K \)

   \( \frac{nRT}{V} T^n = K \)

   \( T^3 = KV \)

   \( 3T^2\Delta T = K\Delta V \)

   \( \frac{3\Delta T}{T} = \frac{\Delta V}{V} \)

   \( \frac{3}{T} = \frac{\Delta V}{\Delta T} \quad \text{[\( \therefore \Delta V = \gamma \Delta T \text{ or } \gamma = \frac{\Delta V}{\Delta T} \)]} \)

   \( \gamma = \frac{3}{T} \)
3. A uniform rod of length 2m and cross sectional area A having density $d$ is rotated with uniform angular velocity $\omega$ about the axis passing through centre of rod. If rotational kinetic energy of rod is $E$, then $\omega = \sqrt{\frac{\alpha E}{Ad}}$. Find $\alpha$?

Ans. 3

Sol. $\text{KE} = \frac{1}{2} I \omega^2$

$E = \frac{1}{2} m \ell^2 \omega^2$

$E = \frac{1}{2} dA \ell^3 \omega^2$

$\omega = \sqrt{\frac{24E}{dA \ell^3}}$

$\omega = \sqrt{\frac{3E}{dA}} = 3$ Ans.

4. A particle is moving with velocity 5m/s for first half distance and remaining half distance for equal time interval its travels with speed 10 m/s and 15 m/s. If average speed $\frac{50}{x}$ m/s find $x$.

Ans. 7

Sol. $d$ meter $d$ meter

$t_1 = \frac{d}{5}$ $t_2 = \frac{10t}{2}$ m $t_3 = \frac{15t}{2}$ m

$d_2 + d_3 = d = \frac{t}{2} (10 + 15)$

$<v> = \frac{2d}{\frac{d}{5} + \frac{2d}{25}} = \frac{2 \times 25}{5 + 2} = 50 \frac{m}{7}$ m/s

Ans. $x = 7$
5. Two isolated solid conducting sphere of radius R and 2R having same surface charge density initially. Now the spheres are connected by thin conducting wire and the surface charge density on the two sphere are $\sigma$ and $\sigma'$ respectively. Find $\frac{\sigma'}{\sigma}$.

(1) 1  (2) 1/2  (3) 1/4  (4) 1/8

Ans. (2)

Sol.

$$Q_1 + Q_2 = 5Q \quad \text{(i)}$$

$$\frac{KQ_1}{R} = \frac{KQ_2}{2R} \Rightarrow Q_2 = 2Q_1 \quad \text{(ii)}$$

From (i) and (ii)

$$Q_1 = \frac{5Q}{3}, Q_2 = \frac{10Q}{3}$$

$$\sigma \left(4\pi R^2\right) = Q_1 \quad \text{iii}$$

$$\sigma' \left(4\pi (2R)^2\right) = Q_2 \quad \text{iv}$$

$$\frac{\sigma}{4\sigma'} = \frac{Q_1}{Q_2} = \frac{1}{2}$$

$$\frac{\sigma}{\sigma'} = 2$$

$$\frac{\sigma'}{\sigma} = \frac{1}{2}$$

6. When heat is absorbed by gas in Isothermal process then which of the following statement is correct.

S-1 $\rightarrow$ Work done by gas is negative
S-2 $\rightarrow$ Work done by gas is positive
S-3 $\rightarrow$ Internal energy is constant
S-4 $\rightarrow$ Internal energy increases
S-5 $\rightarrow$ Internal energy decreases

(1) S – 1 and S – 3 is true  (2) S – 1 and S – 4 is true
(3) S – 2 and S – 3 is true  (4) S – 2 and S – 5 is true

Ans. (3)
Sol.  Temp. = constant

\[ U = \frac{f}{2} \pi RT = \text{constant} \]

\[ \Delta U = \Delta \]

\[ \Delta Q = \Delta U + W \]

+ve = 0 + W

So work done by gas is positive.

7. In a hydrogen atom, velocity of electron in 7th orbit is $0.308 \times 10^6$ m/s. Find velocity of electron in 3rd orbit.

(1) $0.719 \times 10^6$ m/s  (2) $0.819 \times 10^6$ m/s  (3) $1.719 \times 10^6$ m/s  (4) $0.619 \times 10^6$ m/s

Ans. (1)

Sol. \[ v \propto \frac{Z}{n^2} \]

\[ \frac{0.308 \times 10^6}{v_3} = \frac{n_3}{n_7} \]

\[ \frac{0.308 \times 10^6}{v_3} = \frac{3}{7} \]

\[ v_3 = 0.719 \times 10^6 \text{ m/s} \]

8. A point object is placed at 40 cm in front of converging mirror & its real image is obtained at 120 cm. Scale used to measure distances has 20 divisions in 1 cm. Error in focal length is $\frac{1}{K}$ cm. Find K ?

Ans. 32

Sol. \[ \frac{1}{v} + \frac{1}{u} = \frac{1}{f} \]

\[ \therefore \frac{1}{120} - \frac{1}{40} = \frac{1}{f} \Rightarrow f = -30 \text{ cm} \]

Now,

\[ -\frac{1}{v^2} dv - \frac{1}{u^2} du = -\frac{1}{f^2} df \quad \text{&} \quad dv = du = \frac{1}{20} \text{ cm} \]
\[
\therefore \frac{1}{(20)^2} + \frac{1}{(40)^2} = \frac{df}{(30)^2}
\]
\[
\therefore \frac{1}{20} \times \frac{1}{40} \times \frac{1}{40} \left[ \frac{1}{9} + 1 \right] = \frac{df}{30 \times 30}
\]
\[
\therefore \text{df} = \frac{1}{32} \text{ cm}
\]
\[
\therefore \text{k} = 32
\]

9. A capacitor of capacitance 900 \( \mu \text{F} \) is charged to voltage 100 volt. Now it is connected with identical uncharged capacitor. Find out heat produced (in J)

**Ans. 2.25 J**

**Sol.**

\[
\Delta H = \frac{1}{2} \left( \frac{C_1 C_2}{C_1 + C_2} \right) (V_1 - V_2)^2
\]

\[
\Delta H = \frac{1}{2} \times \frac{C \times C}{C + C} (100 - 0)^2
\]

\[
= \frac{1}{2} \times \frac{900 \times 10^{-6}}{2} \times 10^4 = \frac{9}{4} \text{ J} = 2.25 \text{ J}
\]

10. A particle with \( x = A \sin (\omega t) \) is performing SHM with time period \( T \). Its potential energy is maximum for first time at \( t = \frac{T}{4\beta} \), then value of \( \beta \) is:

**Ans. 4**

**Sol.**

P.E. is maximum at \( x_{\text{max}} = A \)

\[
\Rightarrow \quad t' = \frac{T}{4}
\]

\[
\beta = 4
\]
11. Matrix match correct

<table>
<thead>
<tr>
<th>(1)</th>
<th>(P)</th>
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<tbody>
<tr>
<td>![Graph 1](x vs t)</td>
<td>![Graph P](v vs t)</td>
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<tr>
<td>![Graph 4](x vs t)</td>
<td>![Graph S](v vs t)</td>
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**Ans. (1)**

**Sol.** Slope of x-t curve = velocity

12. Find the potential (in volt) of battery so that rod is in equilibrium.

(Given $B = 10^{-3} \text{T}$, $R = 5\Omega$)

![Diagram of rod and magnetic field]

**Ans.** 500 V
13. The heat passing through the cross section of a conductor varies with time ‘t’ as \( Q(t) = \alpha t - \beta t^2 + \gamma t^3 \). Find maximum heat current through the conductor is

\[
(1) \quad \alpha - \frac{\beta^2}{2\gamma} \quad \quad (2) \quad \alpha - \frac{\beta^2}{3\gamma} \quad \quad (3) \quad \alpha - \frac{\beta^2}{\gamma} \quad \quad (4) \quad \alpha - \frac{3\beta^2}{\gamma}
\]

Ans. (2)

Sol.
\[
I = \frac{dQ}{dt} = \alpha - 2\beta t + 3\gamma t^2
\]
\[
\frac{dl}{dt} = 0 - 2\beta + 6\gamma t = 0 \Rightarrow t = \frac{\beta}{3\gamma}
\]

For \( I_{\text{max}} \):
\[
\alpha - 2\beta \left( \frac{\beta}{3\gamma} \right) + 3\gamma \left( \frac{\beta^2}{3\gamma} \right)
\]
\[
= \alpha - \frac{2\beta^2}{3\gamma} + \frac{\beta^2}{3\gamma} = \alpha - \frac{\beta^2}{3\gamma}
\]

14. If in a region the value of gravitational field is \( g = \frac{-k}{x^2} \left( K = \frac{6J}{kg \text{ cm}} \right) \). If potential at \( x = 2 \text{ cm} \) is 10 J/kg. Find potential at \( x = 3 \text{ cm} \).

(1) 9 J/kg  \quad (2) 11 J/kg  \quad (3) 12 J/kg  \quad (4) 8 J/kg

Ans. (2)

Sol.
\[
\int_{V} dv = \int_{V} \bar{g} \cdot d\bar{r}
\]
\[ \int_{10}^{3} \frac{K}{x^2} \, dx = \frac{3}{2} \int_{2}^{2} \frac{K}{x^2} \, dx \]

\[ V - 10 = \left[ \frac{K}{x} \right]_{3}^{2} = -K \left[ \frac{1}{3} - \frac{1}{2} \right] = \frac{K}{6} = 1 \]

\[ \therefore V = 11 \, V \]

15. Two identical mass P and Q are attached by two different strings from same point. If P is released from horizontal position and Q is vertical position. All the collisions are elastic, find velocity of Q just after collision.

**Ans.** 2 m/s

**Sol.** If collision is elastic with same masses velocity get exchange just after collision.

\[ V_Q = \sqrt{2gh} = 2 \, m/s \]
16. An inductor and resistor are connected to A.C. battery source such that \( X_L = R \) and power factor is \( P_1 \). If a capacitor is connected in series to this circuit such that \( X_L = X_C \) and Power factor is \( P_2 \). The ratio \( \frac{P_1}{P_2} = \frac{1}{\sqrt{x}} \). Find \( x \)

**Ans. 2**

**Sol.**

\[ P_1 = \cos \phi = \frac{R}{z} = \frac{R}{\sqrt{R^2 + (x_L)^2}} = \frac{R}{\sqrt{2R^2}} = \frac{1}{\sqrt{2}} \]

\[ P_2 = \cos \phi = \frac{R}{z} = \frac{R}{\sqrt{R^2 + (x_L - x_C)^2}} = \frac{R}{R} = 1 \]

\[ \frac{P_1}{P_2} = \frac{1}{\sqrt{2}} \]

17. In A.M. wave, maximum amplitude 120 volt and minimum 80 volt. Find amplitude of carrier and modulating wave?

(1) 100 V, 20 V  
(2) 20 V, 100 V  
(3) 120 V, 80 V  
(4) 80 V, 120 V

**Ans. (1)**

**Sol.**

\[ 120 = A_c + A_m \quad \ldots (i) \]

\[ 80 = A_c - A_m \quad \ldots (ii) \]

Using equation (i) and (ii)

\[ A_c = 100 \text{ volt} \]

\[ A_m = 20 \text{ volt} \]

18. Surface tension of liquid A and B is \( T \) and \( 2T \) respectively. Density of liquid A and B are \( \rho \) and \( 2\rho \) respectively. Height raised by liquid A is \( 5 \) cm in capillary tube. Find the height raised by liquid B in same capillary tube is ? (Assume contact angle for both liquids are same)

**Ans. 5 cm**

**Sol.**

\[ h = \frac{2T \cos \theta}{\rho g r} \]

\[ 5 = \frac{2T \cos \theta}{\rho g r} \]

\[ h_B = \frac{2(2T) \cos \theta}{2\rho g r} = 5 \text{ cm} \]
19. The relation between bulk modulus $K$, modulus of rigidity and passion's ratio $\sigma$ is:

(1) $\sigma = \frac{3k + 2\eta}{6k - 2\eta}$  
(2) $\sigma = \frac{3k - 2\eta}{6k + 2\eta}$  
(3) $\sigma = \frac{6k - 2\eta}{3k + 2\eta}$  
(4) $\sigma = \frac{6k + 2\eta}{3k - 2\eta}$

Ans. (2)

20. Find the value of $I$ in ampere?

Ans. (1.5)

Sol. 

\[
\begin{align*}
\frac{x - 0}{1} + \frac{x - 2}{1} + \frac{x - y + 5}{1} &= 0 \\
3x + 3 &= y \quad \text{...(1)} \\
y - 0 + y - 5 - x + \frac{y - 2}{2} &= 0 \\
4y - 2x &= 12 \\
\therefore x &= 0 \text{ and } y = 3 \\
\text{Hence } i &= \frac{3}{2} = 1.5 \text{ A}
\end{align*}
\]

21. If the graph between momentum and time is shown below. Find the region of maximum and minimum force. Given : $t_3 - t_2 < t_1$

(1) a, b  
(2) b, c  
(3) a, c  
(4) c, b

Ans. (4)

Sol. $F = \frac{dp}{dt}$ (using graph)
22. If the expression of electric field of wave can be written as
\[ E = \frac{A}{x^2} \hat{j} + \frac{B}{y^3} \hat{j}. \]

Find unit of A, B

(1) \( A = \text{Nm}^2 \text{C}, \) \( B = \text{Nm}^3 \text{C} \)
(2) \( A = \frac{\text{Nm}^2}{\text{C}}, \) \( B = \frac{\text{Nm}^3}{\text{C}} \)
(3) \( A = \frac{N}{C} \text{m}^3, \) \( B = \frac{N}{C} \text{m}^2 \)
(4) None

Ans. (2)

Sol.
\[ \frac{A}{x^2} = \frac{N}{C} \]
\[ A = \frac{N}{C} \text{m}^2 \]
\[ \frac{B}{y^3} = \frac{N}{C} \]
\[ B = \frac{N}{C} \text{m}^3 \]

23. Find out output wave from for input A and B.

Ans. (1)

Sol. De-morgain's law
24. A point source of light of power \( P = 20 \text{ mW} \) is placed at the centre of hemispherical surface of radius \( r = 10 \text{ cm} \). The inner surface of hemisphere is perfectly reflecting. Find the force on hemisphere due to light falling on it?

\[
(1) \quad \frac{5}{3} \times 10^{-11} \text{ N} \quad (2) \quad \frac{20}{3} \times 10^{-11} \text{ N} \quad (3) \quad \frac{10}{3} \times 10^{-11} \text{ N} \quad (4) \quad \frac{40}{3} \times 10^{-11} \text{ N}
\]

Ans. (3)

Sol.

\[
F = \int (P_\theta) \, dA \cos \theta
\]

\[
= \frac{2I}{c} \int dA \cos \theta
\]

\[
= \frac{2I}{c} \pi R^2 = 2 \left( \frac{P}{4 \pi R^2} \right) \frac{\pi R^2}{c}
\]

\[
= \frac{P}{2c} = \frac{20 \times 10^{-3}}{2 \times 3 \times 10^4} = \frac{10}{3} \times 10^{-11} \text{ N}
\]

25. Coil A of radius 10 cm has \( N_A \) number of turns and \( I_A \) current is flowing through it. Coil B of radius 20 cm has \( N_B \) number of turns and \( I_B \) current is flowing through it. If magnetic dipole moment of both the coils is same then

\[
(1) \quad I_A N_A = \frac{1}{2} I_B N_B \quad (2) \quad I_A N_A = 2 I_B N_B \quad (3) \quad I_A N_A = \frac{1}{4} I_B N_B \quad (4) \quad I_A N_A = 4 I_B N_B
\]

Sol. (4)

\[
I_A, N_A, r \quad \text{B}
\]

\[
I_B, N_B, 2r
\]

\[
\vec{M}_1 = \vec{M}_2 \quad (\vec{M} = i\vec{A})
\]

\[
N_A I_A \pi r^2 = N_B I_B \pi (2r)^2
\]

\[
N_A I_A = 4 I_B N_B
\]