PART –A (PHYSICS)

***Questions*: 1:-** On the x-axis and at a distance x from the origin, the gravitational field due to a mass distribution is given by $\frac{Ax}{(x^2+a^2)^{3/2}}$ in the x-direction. The magnitude of gravitational potential on the x-axis at a distance x, taking its value to be zero at infinity is:

(A) $A(x^2+a^2)^{1/2}$

(B) $\frac{A}{(x^2+a^2)^{3/2}}$

(C) $A(x^2+a^2)^{3/2}$

(D) $\frac{A}{(x^2+a^2)^{1/2}}$

***Ans*:- (D)**

$$g=\frac{Ax}{(x^2+a^2)^{3/2}}$$

$$\Rightarrow \quad \int_V^0 dV=-\int_x^\infty g\,dx$$

$$\Rightarrow \quad O-V=-\left[\int\frac{Ax}{(a^2+x^2)^{3/2}}\right]$$

Let, $a^2+x^2=t^2$

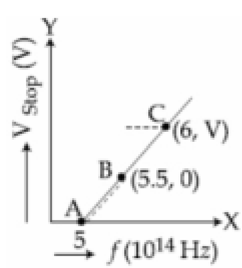
$\Rightarrow \quad 2xdx = 2t\,dt$

$\Rightarrow \quad xdx = tdt$

$$\Rightarrow \quad V=\int\frac{At\,dt}{t^3} \quad \Rightarrow \quad -\frac{A}{t} \quad \Rightarrow \quad -\frac{A}{\sqrt{a^2+x^2}}\Bigg|_x^\infty$$

$$\Rightarrow \quad V=\frac{A}{\sqrt{a^2+x^2}}$$

***Questions*: 2:-** Given figure shows few data points in a photo electric effect experiment for a certain metal. The minimum energy for ejection of electron from its surface is: **(Plancks constant h = 6.62 x 10^{-34} J.s)**



(A) 1.93 eV
(B) 2.10 eV
(C) 2.59 eV
(D) 2.27 eV

***Ans*:- (D)**

$eVs = h\nu - \phi$

At $V_s = 0 \quad \Rightarrow \quad h\nu = \phi$

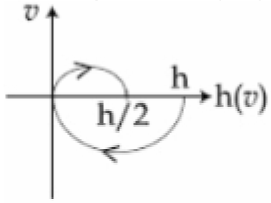
$\Rightarrow \quad \phi = [6.62 \times 10^{-34}]\,[10^{14}]\,[5.5]$

$$\Rightarrow \quad \phi = \frac{[6.62 \times 10^{-34}]\,[10^{14}]\,[5.5]\ eV}{(1.6 \times 10^{-19}]}$$

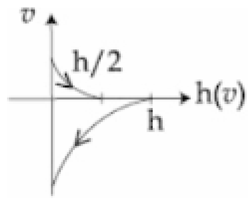
$= 2.27$

***Questions*: 3:-** A Tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\frac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by: **(graphs are drawn schematically and on not to scale)**

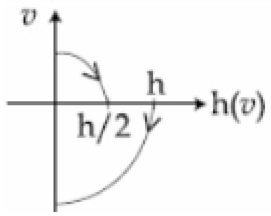
(A)



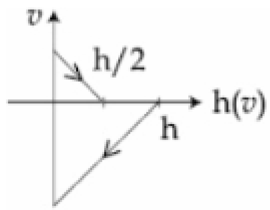
(B)



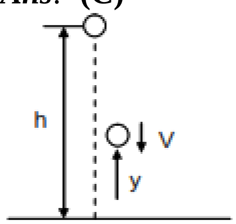
(C)



(D)



***Ans*:- (C)**



$\Rightarrow \quad V^2 = U^2 + 2gS$

$\Rightarrow \quad V^2 = O + 2g\,(h - y)$

$\Rightarrow \quad V^2 = 2gh - 2gy$

$\Rightarrow \quad V = \sqrt{2gh - 2gy}$

***Questions*: 4:-** Dimensional formula for thermal conductivity is **(here K denotes the temperature):**

(A) $MLT^{-3}\,K^{-1}$ (B) $MLT^{-2}\,K^{-2}$

(C) $MLT^{-2}\,K$ (D) $MLT^{-3}\,K$

***Ans*:- (A)**

$$K = \frac{\left(\frac{Q}{t}\right)\Delta x}{A\ \ \Delta T}$$

$$\Rightarrow \quad \frac{(ML^2T^{-2})\,(L)}{(L^2)\,(\theta)\,(T)}$$

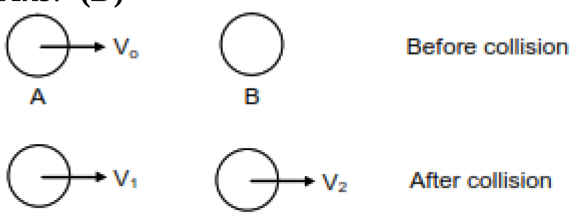
$\Rightarrow \quad M^1\,L^{1-}\,T^{-3}\,\theta^{-1}$

***Questions*: 5:-** Particle A of mass $m_A = \frac{m}{2}$ moving along the x-axis with velocity v_0 collides elastically with another particle B at rest having mass $m_B = \frac{m}{3}$. If both particles move along the x-axis after the collision, the change $\Delta\lambda$ in de-Broglie wavelength of particle A, in terms of its de-Broglie wavelength (λ_0) before collision is:

(A) $\Delta\lambda = \frac{3}{2}\lambda_0$ **(B)** $\Delta\lambda = \frac{5}{2}\lambda_0$

(C) $\Delta\lambda = 2\lambda_0$ **(D)** $\Delta\lambda = 4\lambda_0$

Ans:- **(D)**



$\Rightarrow \quad \vec{V}_1 = 2\overrightarrow{U_{cm}} - \overrightarrow{U_1}$

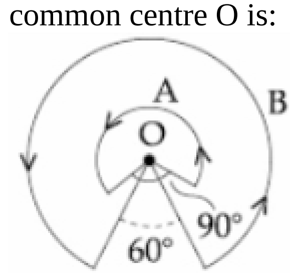
$\Rightarrow \quad 2\left[\dfrac{m/2\ V_o}{\frac{m}{2}+\frac{m}{3}}\right] - V_o$

$\Rightarrow \quad \dfrac{6}{5}V_o - V_o \Rightarrow \dfrac{V_o}{5}$

$\Rightarrow \quad \lambda_o = \dfrac{hc}{\left(\frac{m}{2}V_o\right)} \qquad \lambda_f = \dfrac{hc}{\left(\frac{M}{2}\frac{V_o}{5}\right)}$

$\Rightarrow \quad \Delta\lambda = \dfrac{8hc}{mV_o}$

***Questions*: 6:-** A wire A, bent in the shape of an arc of a circle, carrying a current of 2 A and having radius 2 cm and another wire B, also bent in the shape of arc of a circle, carrying a current of 3 A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic fields due to the wires A and B at the common centre O is:



(A) 6 : 5 (B) 2 : 5

(C) 6 : 4 (D) 4 : 6

Ans:- **(A)**

$$B_A = \frac{\mu_o I\theta}{4\pi R}$$

$$\Rightarrow \quad \frac{B_A}{B_B} = \frac{I_A\theta_A R_B}{I_B\theta_B R_A}$$

$$\Rightarrow \quad \frac{2\left(\frac{3\pi}{2}\right)(4)}{3\left[\frac{5\pi}{3}\right][2]}$$

$$\Rightarrow \quad \frac{6}{5}.$$

***Questions*: 7:-** The specific heat of water = 4200 J kg^{-1} K^{-1} and the latent heat of ice = 3.4 x 10^5 J kg^{-1}. 100 grams of ice at 0°C is placed in 200 g of water at 25°C. The amount of ice that will melt as the temperature of water reaches 0°C is close to (in grams):

(A) 64.6 **(B)** 61.7

(C) 69.3 **(D)** 63.8

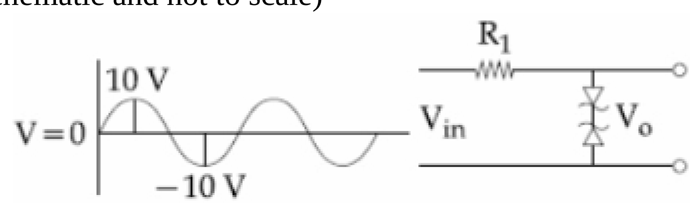
***Ans*:- (B)**

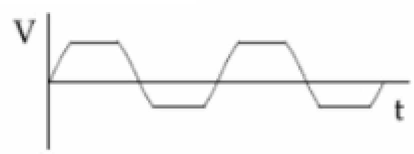
$m(L) = m_1S_1\,(\Delta T)$

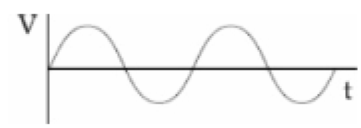
$\Rightarrow \quad m(3.4 \times 10^5) = (200)\,(4200)\,(25)$

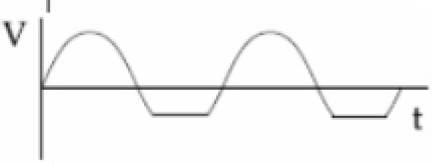
$\Rightarrow \quad m = 61.7$

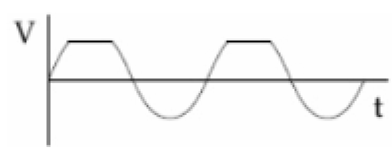
***Questions*: 8:-** Take the breakdown voltage of the zener diode used in the given circuit as 6V. For the input voltage shown in figure below, the time variation of the output voltage is:
(Graphs drawn are schematic and not to scale)



(A)


(B)


(C)


(D)


***Ans*:- (A)**

***Questions*: 9:-** A beam of plane polarized light of large cross-sectional area and uniform intensity of 3.3 Wm^{-2} falls normally on a polarizer (cross sectional area 3 x 10^{-4} m^2) which rotates about its axis with an angular speed of 31.4 rad/s. The energy of light passing through the polariser per revolution, is close to:

(A) 1.0 x 10^{-5} J **(B)** 1.5 x 10^{-4} J

(C) 5.0 x 10^{-4} J **(D)** 1.0 x 10^{-4} J

***Ans*:- (D)**

$E = (I)\,(t)\,(A)\,\langle \cos^2\theta \rangle$

$\Rightarrow \quad (3.3)\left[\dfrac{2\pi}{31.4}\right][3\times10^{-4}]\times\dfrac{1}{2}$

$\Rightarrow \quad 0.99 \times 10^{-4}$

***Questions*: 10:-** A small bar magnet placed with its axis at 30° with an external field of 0.06 T experiences a torque of 0.018 Nm. The minimum work required to rotate it from its stable to unstable equilibrium position is:

(A) 11.7×10^{-3} J **(B)** 9.2×10^{-3} J

(C) 7.2×10^{-2} J **(D)** 6.4×10^{-2} J

***Ans*:- (D)**

$\vec{\tau} = \vec{\mu} \times \vec{B}$

$\Rightarrow \quad 0.018 = \mu(0.06)\,(\sin 30°)$

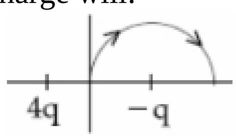
$\Rightarrow \quad \mu = 0.6$

$\Rightarrow \quad \text{Work} = U_f - U_i$

$\Rightarrow \quad 2\mu B$

$\Rightarrow \quad 7.2 \times 10^{-2}$ J.

***Questions*: 11:-** A two point charges 4q and – q are fixed on the x - axis at $x = -\frac{d}{2}$ and $x = \frac{d}{2}$, respectively. If a third point charge 'q' is taken from the origin to x = d along the semicircle as shown in the figure, the energy of the charge will:



(A) decrease by $\dfrac{4q^2}{3\pi\epsilon_0 d}$ (B) increase by $\dfrac{2q^2}{3\pi\epsilon_0 d}$

(C) increase by $\dfrac{3q^2}{4\pi\epsilon_0 d}$ (D) decrease by $\dfrac{q^2}{4\pi\epsilon_0 d}$

***Ans*:- (A)**

$U_{\text{initial}} = \dfrac{k(4q)(q)}{(d/2)} + \dfrac{k(q)(-q)}{(d/2)}$

$\Rightarrow \quad \dfrac{6kq^2}{d}$

$\Rightarrow \quad U_{\text{final}} = \dfrac{4(4q)(q)}{\left(\dfrac{3d}{2}\right)} + \dfrac{k(q)(-q)}{(d/2)}$

$\Rightarrow \quad \dfrac{2}{3}\dfrac{kq^2}{d}$

$\Rightarrow \quad \Delta U = \left(\dfrac{2}{3} - 6\right)\dfrac{kq^2}{d} \quad \Rightarrow \quad \dfrac{-16}{3}\,\dfrac{kq^2}{d}$

***Questions*: 12:-** Choose the correct option relating wavelengths of different parts of electromagnetic wave spectrum:

(A) $\lambda_{x-rays} < \lambda_{micro\ waves} < \lambda_{radio\ waves} < \lambda_{visible}$ (B) $\lambda_{visible} < \lambda_{micro\ waves} < \lambda_{radio\ waves} < \lambda_{x-rays}$

(C) $\lambda_{visible} > \lambda_{x-rays} > \lambda_{radio\ waves} > \lambda_{micro\ waves}$ (D) $\lambda_{radio\ waves} > \lambda_{micro\ waves} > \lambda_{visible} > \lambda_{x-rays}$

Ans:- **(D)**

Questions**: 13:-** Match the C_P/C_V ratio for ideal gases with different type of molecules:

	Molecule Type		**C_P/C_V**
(A)	Monatomic	(i)	$\frac{7}{5}$
(B)	Diatomic rigid molecules	(ii)	$\frac{9}{7}$
(C)	Diatomic non-rigid molecules	(iii)	$\frac{4}{3}$
(D)	Triatomic rigid molecules	(iv)	$\frac{5}{3}$

Match the correct option?

(A) A → III; B → IV; C → II; D → I
(B) A → IV; B → I; C → II; D → III
(C) A → II; B → III; C → I; D → IV
(D) A → IV; B → II; C → I; D → III

Ans:- **(B)**

Mono atomic $\longrightarrow C_V = \frac{3R}{2} \quad C_p = \frac{5R}{2}$

Di- atomic $\longrightarrow C_V = \frac{5R}{2} \quad C_p = \frac{7R}{2}$

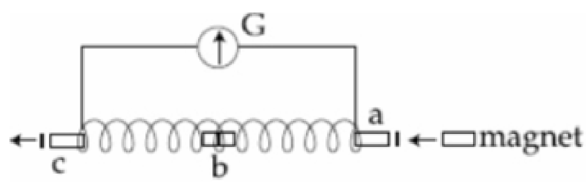
(Rigid)

Di-atomic $\longrightarrow C_V = \frac{7R}{2} \quad C_p = \frac{9R}{2}$

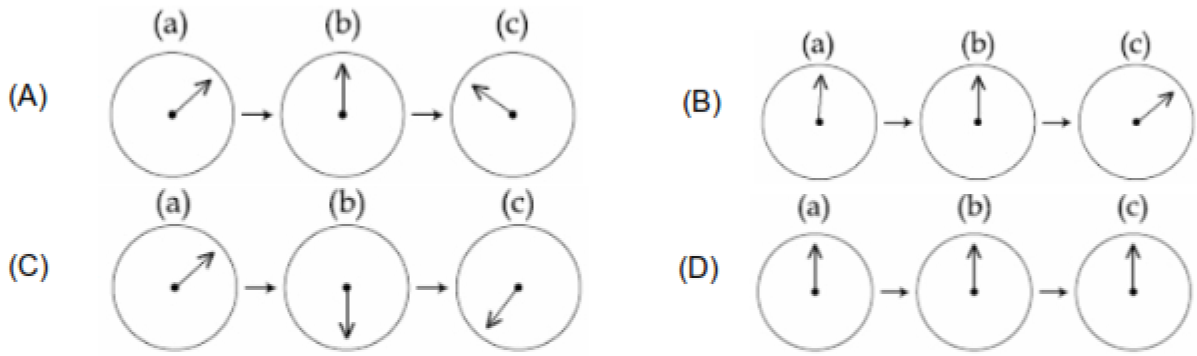
(Non-Rigid)

Tri–atomic $\longrightarrow C_V = 3R \quad C_P = 4R$
(Rigid)

Questions**: 14:-** A small bar magnet is moved through a coil at constant speed from one end to the other. Which of the following series of observations will be seen on the galvanometer G attached across the coil?



Three positions shown describe:
(a) The magnet's entry
(b) Magnet is completely inside and
(c) Magnet's exit



Ans:- **(A)**

***Questions*: 15:-** For a transverse wave traveling along a straight line, the distance between two peaks (crests) is 5 m, while the distance between one crest and one trough is 1.5 m. The possible wavelengths (in m) of the waves are:

(A) 1, 3, 5,…… **(B)** $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}, \ldots$

(C) $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}, \ldots$ **(D)** 1, 2, 3,……

Ans:- (B)

(n) $\lambda = 5$

(n, m): Integers

$$\left(\frac{2m+1}{2}\right)\lambda = \frac{3}{2}$$

$$\Rightarrow \quad \frac{3/2}{5} = \frac{2m+1}{2n}$$

$$\Rightarrow \quad 3n = 10\,m + 5$$

N, m are integers.

So, $m = 1,\quad n = 5,\quad \lambda = 1$

$m = 4 \quad n = 15 \quad \lambda = \frac{1}{3}$

$m = 7 \quad n = 25 \quad \lambda = \frac{1}{5}$

***Questions*: 16:-** A air bubble of radius 1 cm in water has an upward acceleration 9.8 cm s^{-2} . The density of water is 1 gm cm^{-3} and water offers negligible drag force on the bubble. The mass of the bubble is:

(g = 980 cm/s^2)

(A) 4.51 gm **(B)** 1.52 gm

(C) 3.15 gm **(D)** 4.15 gm

Ans:- **(D)**

$\rho vg - mg = ma$

$\Rightarrow \quad \frac{\rho vg}{m} = g + a$

$\Rightarrow \quad m = \frac{\rho vg}{g + a}$

$\Rightarrow \quad \frac{10^3\left(\frac{4}{3}\pi \times 10^{-6}\right)(9.8)}{9.898}$

$\Rightarrow \quad 4.15$ gm

***Questions*: 17:-** Starting from the origin at time t = 0, with initial velocity $5\hat{j} = ms^{-1}$, a particle moves in the x – y plane with a constant acceleration of $(10\hat{i} + 4\hat{j})ms^{-2}$. At time t, its coordinates are (20m, y_0 m). The values of t and y_0 are, respectively:

(A) 2 s and 24 m **(B)** 4 s and 52 m

(C) 5 s and 25 m **(D)** 2 s and 18 m

***Ans*:- (D)**

$\vec{U} = 5\hat{j}$

$\vec{a} = 10\hat{i} + 4\hat{j}$

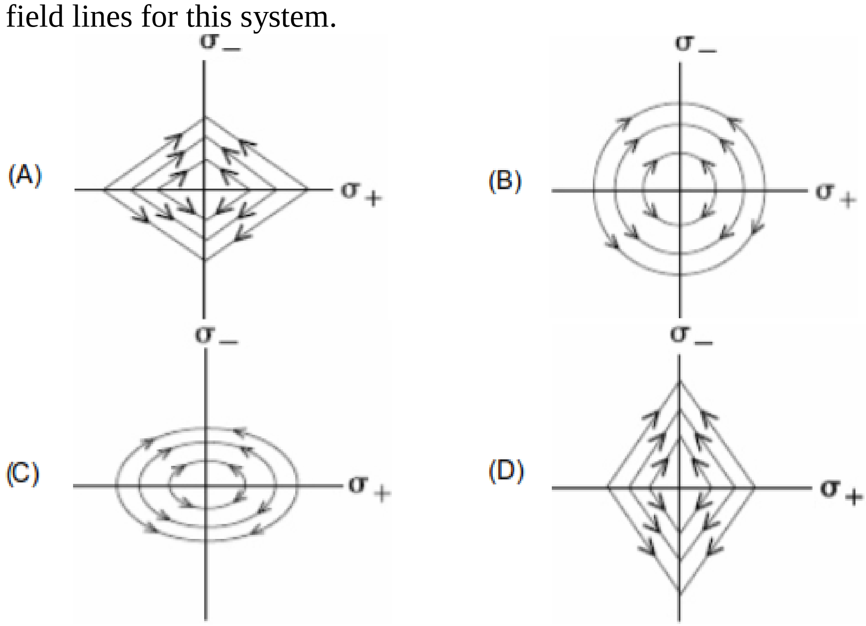
$\Rightarrow \quad \vec{S} = \vec{U}t + \frac{1}{2}(\vec{a})t^2$

$\Rightarrow \quad 20\hat{i} + y_o\hat{j} = (5t^2)\hat{i} + (5t + 2t^2)\hat{j}$

$20 = 5t^2 \quad ; \quad y_o = 5t + 2t^2$

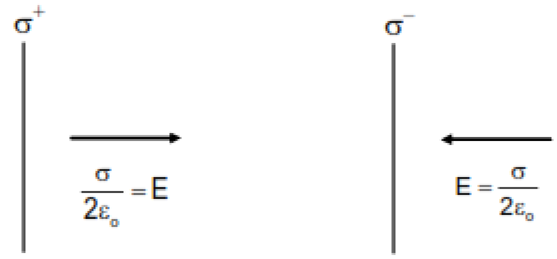
$t = 2 \quad \Rightarrow \quad 18$ m.

***Questions*: 18:-** Two charged thin infinite plane sheets of uniform surface charge density σ_+ and σ_-, where $|\sigma_+| > |\sigma_-|$, intersect at right angle. Which of the following best represents the electric field lines for this system.

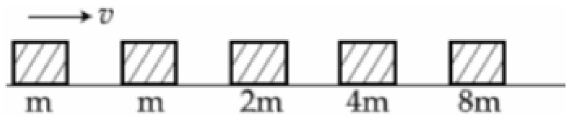


***Ans*:- (D)**

⇒ Electric field due to infinite sheet is uniform.

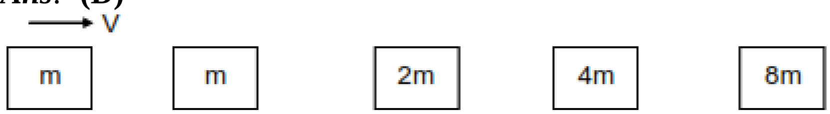


***Questions*: 19:-** Blocks of masses m, 2m and 8m are arranged in a line on a frictionless floor. Another block of mass m, moving with speed v along the same line (see figure) collides with mass m in perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. By the time the last block of mass 8m starts moving the total energy loss is p% of the original energy. Value of 'p' is close to:



(A) 77 **(B)** 37
(C) 87 **(D)** 94

***Ans*:- (D)**



⇒ $mv = 16\ mv_1$

⇒ $V_1 = \frac{V}{16}$

⇒ $\Delta k \text{ loss} = \frac{1}{2}mv^2 - \frac{1}{2}(16m)\left(\frac{V}{16}\right)^2$

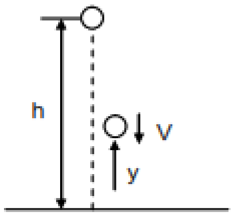
⇒ $\frac{1}{2}mv^2\left(\frac{15}{16}\right)$

$\% \text{ loss} = \frac{15}{16}\times 100 = 93.75\%$

***Questions*: 20:-** A battery of 3.0 V is connected to a resistor dissipating 0.5 W of power. If the terminal voltage of the battery is 2.5 V, the power dissipated within the internal resistance is:

(A) 0.50 W **(B)** 0.10 W
(C) 0.125 W **(D)** 0.072 W

***Ans*:- (B)**



(1) $\varepsilon = 3$

(2) $\varepsilon - Ir = 2.5$ V

$\Rightarrow$ $Ir = 0.5$

Now, $IR = 2.5$

$\Rightarrow$ $\dfrac{R}{r} = 5.$

$\Rightarrow$ $\dfrac{P_R}{R_r} = \dfrac{I^2R}{I^2r} = \dfrac{R}{r} = 5$

$\Rightarrow$ $P_r = \dfrac{0.5}{5} = 0.1$