JEE-MAIN-2020 (6th September-First Shift)-PCM-2

PART –A (PHYSICS)

***Questions*: 1:-** A screw gauge has 50 divisions on its circular scale. The circular scale is 4 units ahead of the pitch scale marking, prior to use. Upon one complete rotation of the circular scale, a displacement of 0.5 mm is noticed on the pitch scale. The nature of zero error involved, and the least count of the screw gauge, are respectively:

(A) Negative, 2 μm **(B)** Positive, 10 μm

(C) Positive, 0.1 mm **(D)** Positive, 0.1 μm

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

$$\text{L.C.} = \frac{0.5\ \text{mm}}{50}$$

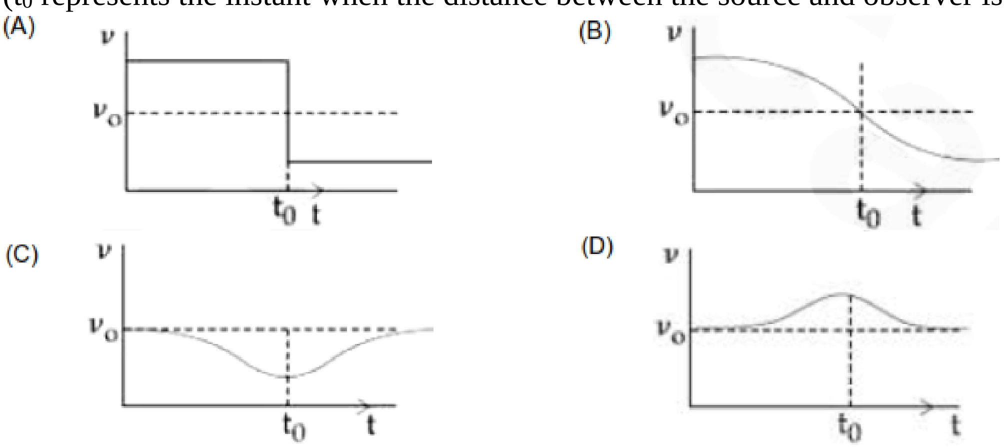
$$= 10^{-2}\ \text{mm}$$

$$= 10^{-5}\ \text{m}$$

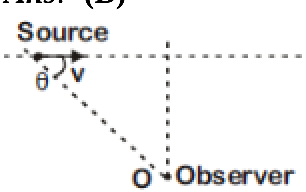
$$= 10\ \mu\text{m}$$

***Questions*: 2:-** A sound source S is moving along a straight track with speed v, and is emitting sound of frequency ν_0 (see figure). An observer is standing at a finite distance, at the point O, from the track. The time variation of frequency heard by the observer is best represented by:

(t_0 represents the instant when the distance between the source and observer is minimum)



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



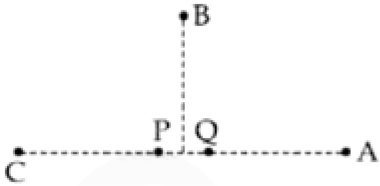
While approaching

$$v = v_0\left(\frac{c}{c - v\cos\theta}\right)$$

While receding

$$v = v_0\left(\frac{c}{c + v\cos\theta}\right)$$

***Questions*: 3:-** In the figure below, P and Q are two equally intense coherent sources emitting radiation of wavelength 20 m. The separation between P and Q is 5 m and the phase of P is ahead of that of Q by 90°. A, B and C are three distinct points of observation, each equidistant from the midpoint of PQ. The intensities of radiation at A, B, C will be in the ratio:



(A) 0 : 1 : 4 **(B)** 2 : 1 : 0

(C) 0: 1 : 2 **(D)** 4 : 1 : 0

Ans:- **(B)**

$$\phi_A = \frac{\pi}{2} - \frac{2\pi}{\lambda} \times \frac{5}{20} = 0$$

$$\phi_B = \frac{\pi}{2}$$

$$\phi_C = \frac{\pi}{2} + \frac{2\pi}{\lambda} \times \frac{5}{20} = \pi$$

$I_A = 4I_0$; $I_B = 2I_0$; $I_C = 0$

***Questions*: 4:-** If the potential energy between two molecules in given by $U = \frac{A}{r^6} + \frac{B}{r^{12}}$, then at equilibrium, separation between molecules, and the potential energy are:

(A) $\left(\frac{B}{2A}\right)^{1/6}, -\frac{A^2}{2B}$ (B) $\left(\frac{B}{A}\right)^{1/6}, 0$

(C) $\left(\frac{2B}{A}\right)^{1/6}, -\frac{A^2}{4B}$ (D) $\left(\frac{2B}{A}\right)^{1/6}, -\frac{A^2}{2B}$

Ans:- **(C)**

$$F = -\frac{dU}{dr} = -\left[\frac{6A}{r^7} - \frac{12B}{r^{13}}\right]$$

$F = 0$

$$\Rightarrow \quad r = \left(\frac{2B}{A}\right)^{1/6}$$

$$U\left(\text{at } r = \left(\frac{2B}{A}\right)^{1/6}\right) = -\frac{A^2}{4B}$$

***Questions*: 5:-** An AC circuit has R 100Ω, C = μF and L = 80 mH, connected in series. The quality factor of the circuit is:

(A) 2 **(B)** 0.5

(C) 20 **(D)** 400

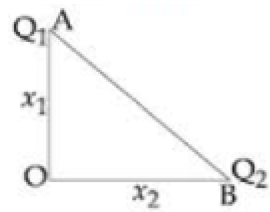
Ans:- **(A)**

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$= \frac{1}{100}\sqrt{\frac{80 \times 10^{-3}}{2 \times 10^{-6}}}$$

$$= 2$$

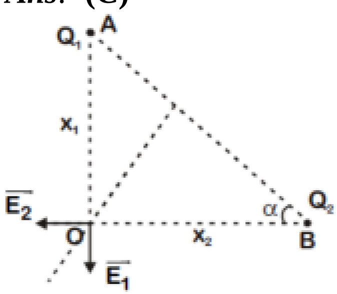
***Questions*: 6:-** Charge Q_1 and Q_2 are at point A and B of a right angle triangle OAB (see figure). The resultant electric field at point O is perpendicular to the hypotenuse, then $\frac{Q_1}{Q_2}$ is proportional to:



(A) $\frac{x_1^3}{x_2^3}$ **(B)** $\frac{x_2}{x_1}$

(C) $\frac{x_1}{x_2}$ **(D)** $\frac{x_2^2}{x_1^2}$

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



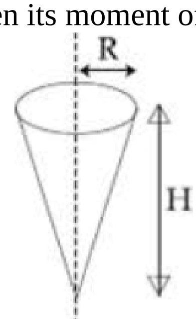
Net field along AB at O must be zero.

$E_2 \cos \alpha = E_1 \sin\alpha$

$$\frac{kQ_2}{x_2^2} \cdot \frac{x_2}{AB} = \frac{kQ_1}{x_1^2} \cdot \frac{x_1}{AB}$$

$$\frac{Q_1}{Q_2} = \frac{x_1}{x_2}$$

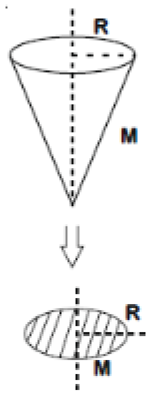
***Questions*: 7:-** Shown in the figure is a hollow icecream cone (it is open at the top). If its mass is M, radius of its top, R and height, H, then its moment of inertia about its axis is:



(A) $\frac{MR^2}{2}$ **(B)** $\frac{M(R^2+H^2)}{4}$

(C) $\frac{MH^2}{3}$ **(D)** $\frac{MR^2}{3}$

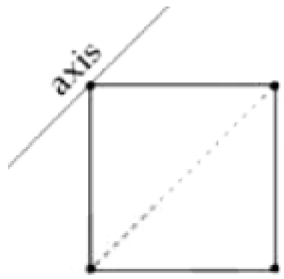
***Ans*:- (A)**



$$I = \frac{MR^2}{2}$$

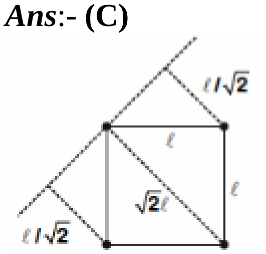
Moment of inertia of this cone will same as circular disk of mass (M) and radius R.

***Questions*: 8:-** Four point masses, each of mass m, are fixed at the corners of a square of side l. The square is rotating with angular frequency ω, about an axis passing through one of the corners of the square and parallel to its diagonal, as shown in the figure. The angular momentum of the square about this axis is:



(A) $ml^2\,\omega$ (B) $5ml^2\,\omega$
(C) $3ml^2\,\omega$ (D) $2ml^2\,\omega$

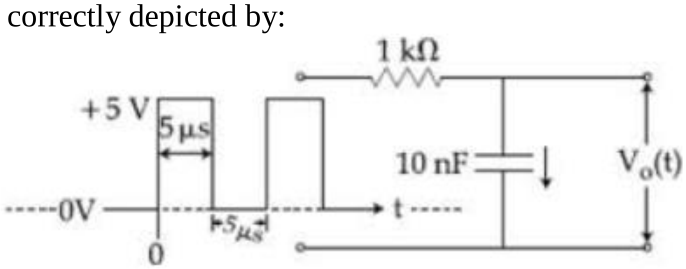
***Ans*:- (C)**



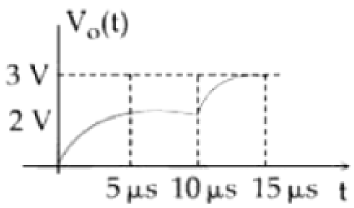
$$I = m\left(\frac{\ell^2}{2}\right)\times 2 + m\times(\sqrt{2}\,\ell)^2 = 3m\ell^2$$

$$\therefore \quad L = I\omega = 3m\ell^2\omega$$

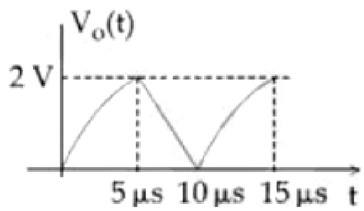
***Questions*: 9:-** For the given input voltage waveform $V_{in}(t)$, the output voltage waveform $V_0(t)$, across the capacitor is correctly depicted by:



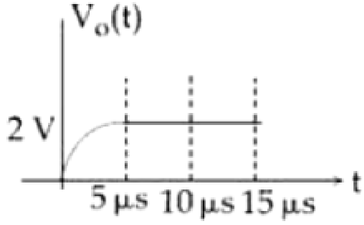
(A)



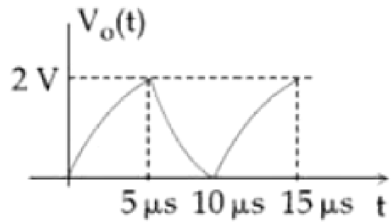
(B)



(C)



(D)



Ans:- **(A)** τ = RC = 10 µs

For 0 < t < 5 µs, it will get charged. For 5 < t < 10 □s potential is constant and again gets charged after that.

***Questions*: 10:-** A particle of charge q and mass m is moving with a velocity $-v\hat{i}(v \neq 0)$ towards a large screen placed in the Y – Z plane at a distance d. If there is a magnetic field $\overline{B} = B_0\hat{k}$, the minimum value of v for which the particle will not hit the screen is:

(A) $\frac{qdB_0}{3m}$ **(B)** $\frac{2qdB_0}{m}$

(C) $\frac{qdB_0}{m}$ **(D)** $\frac{qdB_0}{2m}$

Ans:- **(C)**

$r = \frac{mv}{qB_0}$

To not collide, r < d

$\Rightarrow \quad \frac{mv}{qB_0} < d$

$\therefore \quad v_{max} = \frac{qB_0 d}{m}$

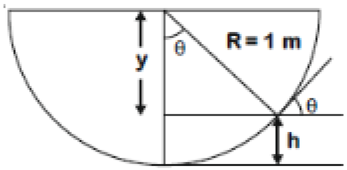
Note: It should be maximum instead of minimum.

***Questions*: 11:-** An insect is at the bottom of a hemispherical ditch or radius 1 m. It crawls up the ditch but starts slipping after it is at height h from the bottom. If the coefficient of friction between the ground and the insect is: 0.75, then h is: (g = 10ms^{-2})

(A) 0.20 m **(B)** 0.45 m

(C) 0.60 m **(D)** 0.80 m

Ans:- **(A)**



$\mu = \tan\theta$

$\Rightarrow \quad \frac{3}{4} = \tan\theta$

$\Rightarrow \quad \theta = 37°$

$\therefore \quad h = R - R\cos\theta = 1 - 1 \times \frac{4}{5} = 0.2\,m$

***Questions*: 12:-** A satellite is in an elliptical orbit around a planet P. It is observed that the velocity of the satellite when it is farthest from the planet is 6 times less than that when it is closest to the planet. The ratio of distances between the satellite and the planet at closest and farthest points is:

(A) 1 : 6 **(B)** 1 : 3

(C) 1 : 2 **(D)** 3 : 4

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

$$\frac{V_{max}}{V_{min}} = \frac{(1+e)}{(1-e)}$$

$$\frac{r_{max}}{r_{min}} = \frac{(1+e)}{1-e} = 6$$

***Questions*: 13:-** An electron, a doubly ionized helium ion (He^{++}) and a proton are having the same kinetic energy. The relation between their respective de – Broglie wavelength λ_e, λ_{He++} and λ_p is:

(A) $\lambda_e > \lambda_{He++} > \lambda_P$ **(B)** $\lambda_e < \lambda_{He++} = \lambda_P$

(C) $\lambda_e > \lambda_P > \lambda_{He++}$ **(D)** $\lambda_e < \lambda_P < \lambda_{He++}$

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

$$\lambda = \frac{h}{p}$$

$$p = \sqrt{2mk}$$

$$\lambda \propto \frac{1}{\sqrt{m}}$$

***Questions*: 14:-** A clock has a continuously moving second's hand of 0.1 m length. The average acceleration of the tip of the hand (in units of ms^{-2}) is of the order of:

(A) 10^{-3} **(B)** 10^{-4}

(C) 10^{-2} **(D)** 10^{-1}

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

$a = \omega^2 \times \ell$

$$= \left(\frac{2\pi}{T}\right)^2 \times 0.1$$

$$= \left(\frac{2\pi}{60}\right)^2 \times 0.1$$

$= 1.1 \times 10^{-3}$ m/s^2

***Questions*: 15:-** You are given that Mass of ${}^{7}_{2}\mathrm{Li} = 7.0160\mathrm{u}$ mass of ${}^{4}_{2}\mathrm{He} = 4.0026\mathrm{u}$ and ${}^{1}_{1}\mathrm{H} = 1.0079\mathrm{u}$. When 20 g of ${}^{7}_{3}\mathrm{Li}$ is converted into ${}^{4}_{2}\mathrm{He}$ by proton capture, the energy liberated, (in kWh), is [Mass of nucleon $= \frac{1\mathrm{Gev}}{c^2}$]

(A) 4.5×10^5 **(B)** 8×10^6

(C) 6.82×10^5 **(D)** 1.33×10^6

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

${}^{7}_{3}\mathrm{Li} + {}^{1}_{1}\mathrm{H} \longrightarrow 2\,{}^{4}_{2}\mathrm{He}$

$\Delta m = (m_{Li} + m_H - 2m_{He})$

$= .0187$ u

Q value $= \Delta mc^2$

$= 17.42$ MeV

Energy liberated $= \frac{20}{7} \times 6.023 \times 10^{23} \times (Q - \text{value})$

$\simeq 300 \times 10^{29}$ eV

$\simeq 480 \times 10^{10}$ J

$= 1.33 \times 10^6$ kWh

***Questions*: 16:-** A point like object is placed at a distance of 1 m in front of convex lens of focal length 0.5 m. A plane mirror is placed at a distance of 2m behind the lens. The position and nature of the final image formed by the system is:

(A) 2.6 m from the mirror, real **(B)** 1 m from the mirror, virtual

(C) 1 m from the mirror, real **(D)** 2.6 m from the mirror, virtual

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

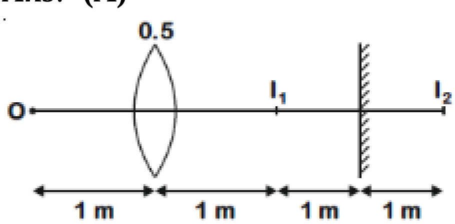


Image formed by one will be object for other.

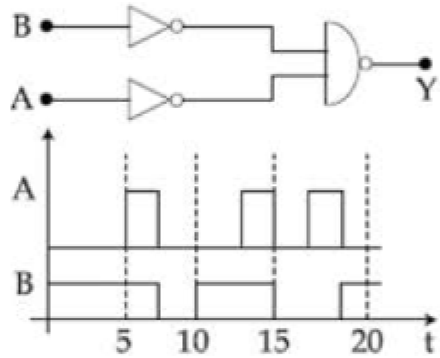
$$\frac{1}{v_1} + \frac{1}{1} = \frac{1}{0.5} \Rightarrow v_1 = 1\mathrm{m}$$

I_2 will be formed in behind the mirror.

$$\frac{1}{v_3} + \frac{1}{3} = \frac{1}{0.5} \Rightarrow v_3 = 0.6\,\mathrm{m}$$

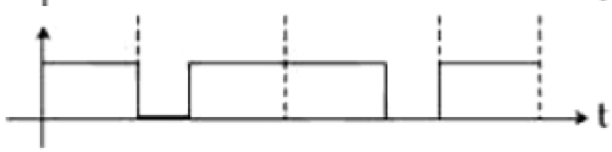
So, final image will be formed at 2.6 m from the mirror, real.

***Questions*: 17:-** Identify the correct output signal Y in the given combination of gates (as shown) for the given inputs A and B.

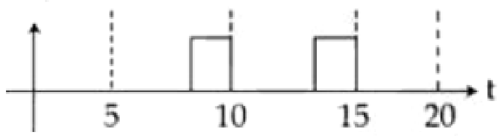


(A)

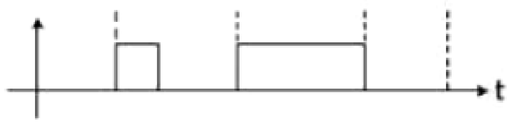
(B)



(C)



(D)



***Ans*:- (None)**

$Y = \overline{\overline{A} \cdot \overline{B}} = \overline{\overline{A}} + \overline{\overline{B}} = A + B$

Truth table

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

***Questions*: 18:-** Molecules of an ideal gas are known to have three translational degrees of freedom and two rotational degrees of freedom. The gas is maintained at a temperature of T. The total internal energy, U of a mole of this gas, and the value of $\gamma \left(= \frac{C_P}{C_v}\right)$ are given, respectively, by:

(A) $U = \frac{5}{2}RT$ and $\gamma = \frac{6}{5}$ **(B)** $U = 5RT$ and $\gamma = \frac{7}{5}$

(C) $U = \frac{5}{2}RT$ and $\gamma = \frac{7}{5}$ **(D)** $U = 5RT$ and $\gamma = \frac{6}{5}$

Ans:- **(C)**

$f = 5$

$\therefore \quad U = \frac{5}{2}RT$

And $\gamma = 1 + \frac{2}{f} = 1 + \frac{2}{5} = \frac{7}{5}$

***Questions*: 19:-** An object of mass m is suspended at the end of a massless wire of length L and area of cross – selection, A. Young modulus of the material of the wire is Y. If the mass is pulled down slightly its frequency of oscillation along the vertical direction is:

(A) $f = \frac{1}{2\pi}\sqrt{\frac{mL}{YA}}$ **(B)** $f = \frac{1}{2\pi}\sqrt{\frac{YA}{mL}}$

(C) $f = \frac{1}{2\pi}\sqrt{\frac{mA}{YL}}$ **(D)** $f = \frac{1}{2\pi}\sqrt{\frac{YL}{mA}}$

Ans:- **(B)**

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$k = \frac{YA}{L}$

$f = \left(\frac{1}{2\pi}\right)\sqrt{\frac{YA}{mL}}$

***Questions*: 20:-** An electron is moving along + x direction with a velocity of 6×10^6 ms^{-1}. It enters a region of uniform electric field of 300 V/cm pointing along + y direction. The magnitude and direction of the magnetic field set up in this region such that the electron keeps moving along the x direction will be:

(A) 3×10^{-4} T, along + z direction **(B)** 5×10^{-3} T, along – z direction

(C) 5×10^{-3} T, along + z direction **(D)** 3×10^{-4} T, along – z direction

Ans:- **(C)**

$F = q(\vec{E} + \vec{V} \times \vec{B})$

$\vec{E} + \vec{V} \times \vec{B} = 0$