JEE-MAIN-2020 (2 September-First Shift)

PART –A (PHYSICS)

***Questions*: 1:-** A plane electromagnetic wave, has frequency of 2.0 x 10^{10} Hz and its energy density is 1.02 x 10^{-8} J/m^3 in vacuum. The amplitude of the magnetic field of the wave is close to

$(\frac{1}{4\pi \epsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$ and speed of light = 3 × 108 ms^{-1}) :

(A) 150 nT **(B)** 180 nT

(C) 190 nT **(D)** 160 nT

***Ans*:- D**

$$\text{Energy Density} = \frac{1}{2}\frac{B^2}{\mu_0}$$

$$B = \sqrt{2 \times \mu_0 \times \text{Energy density}}$$

$$B = \sqrt{2 \times 4\pi \times 10^{-7} \times 1.02 \times 10^{-8}} = 160 \times 10^9 = 160 \text{ nT}$$

***Questions*: 2:-** Magnetic materials used for making permanent magnets (P) and magnets in a transformer (T) have different properties of the following, which property best matches for the type of magnet required ?

(A) T : Large retentivity, large coercivity **(B)** P : Small retentivity, large coercivity

(C) P : Large retentivity, large coercivity **(D)** T : Large retentivity, small coercivity

***Ans*:- B**

Based on theory.

***Questions*: 3:-** Two identical strings X and Z made of same material have tension T_x and T_Z in then If their fundamental frequencies are 450 Hz and 300 Hz, respectively, then the ratio T_x/T_Z is:

(A) 1.25 **(B)** 2.25

(C) 1.5 **(D)** 0.44

***Ans*:- B**

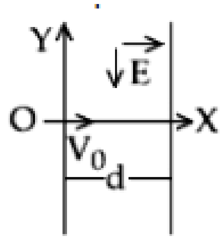
$$f_x = \frac{1}{2\ell}\sqrt{\frac{T_x}{\mu}}$$

$$f_y = \frac{1}{2\ell}\sqrt{\frac{T_y}{\mu}}$$

$$\frac{f_x}{f_y} = \frac{450}{300} = \sqrt{\frac{T_x}{T_y}}$$

$$\Rightarrow \quad T_x/T_y = 9/4 = 2.25$$

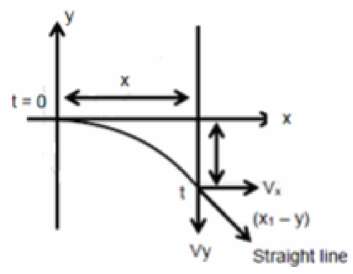
***Questions*: 4:-** A charged particle (mass m and charge q) moves along X axis with velocity V_0. When it passes through the origin it enters a region having uniform electric field $\vec{E} = -E\hat{j}$ which extends upto x = d. Equation of path of electron in the region x > d is:



(A) $y=\frac{qEd}{mV_0^2}\left(\frac{d}{2}-x\right)$ **(B)** $y=\frac{qEd}{mV_0^2}x$

(C) $y=\frac{qEd^2}{mV_0^2}x$ **(D)** $y=\frac{qEd}{mV_0^2}(x-d)$

Ans:- A



x > d path is straight line

$$\frac{-y=\frac{1}{2}at^2}{x-d}=\frac{at}{V_0}$$

$$\frac{-y-\frac{1}{2}a^2}{at}=\frac{x-d}{V_0}$$

$$\frac{-y}{at}-\frac{1}{2}\frac{d}{V_0}=\frac{x}{V_0}-\frac{d}{V_0}$$

$$-\frac{myV_0}{qEd}=\frac{x}{V_0}-\frac{d}{2V_0}$$

$$y=\frac{-qEd}{mV_0}\left(\frac{x}{V_0}-\frac{d}{2V_0}\right)\ ;\ y=\frac{qEd}{mV_0^2}\left(\frac{d}{2}-x\right)$$

***Questions*: 5:-** The least count of the main scale of a vernier callipers is 1 mm. Its vernier scale is divided into 10 divisions and coincide with 9 divisions of the main scale. When jaws are touching each other, the 7th division of vernier scale coincides with a division of main scale and the zero of vernier scale is lying right side of the zero of main scale. When this vernier is used to measure length of cylinder the zero of the vernier scale between 3.1 cm and 3.2 cm and 4th VSD coincides with a main scale division. The length of the cylinder is (VSD is vernier scale division)

(A) 3.21 cm **(B)** 3.07 cm

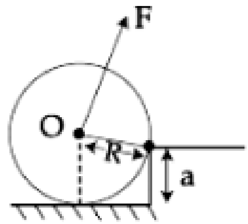
(C) 3.2 cm **(D)** 2.99 cm

***Ans*:- B**

Zero error = 0 + 7 × 0.1 = 0.070

Vernier reading = (3.1 + 4 × 0.01) –0.07 = 3.07

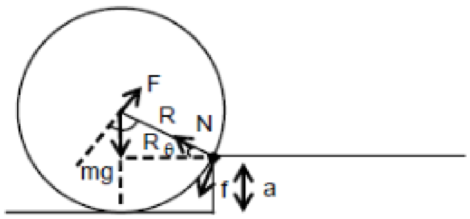
***Questions*: 6:-** A uniform cylinder of mass M and radius R is to be pulled over a step of height a (a < R) by applying a force F at its centre 'O' perpendicular to the plane through the axes of the cylinder on the edge of the step (see figure). The minimum value of F required is:



(A) $Mg\sqrt{1-\frac{a^2}{R^2}}$ **(B)** $Mg\sqrt{1-\left(\frac{R-a}{R}\right)^2}$

(C) $Mg\sqrt{\left(\frac{R}{R-a}\right)^2-1}$ **(D)** $Mg\frac{a}{R}$

Ans:- **B**



$FR > mg\cos\theta\, R$

$F > mg\cos\theta$

$F > mg\frac{\sqrt{R^2-(R-a)^2}}{R} \Rightarrow Mg\sqrt{1-\left(\frac{R-a}{R}\right)^2}$

Questions: **7:-** The mass density of a spherical galaxy varies as $\frac{K}{r}$ over a large distance 'r' from its center. In that region, a small star is in a circular orbit of radius R. Then the period of revolution, T depends on R as:

(A) $T \propto R$ **(B)** $T^2 \propto R^3$

(C) $T^2 \propto \frac{1}{R^3}$ **(D)** $T^2 \propto R$

Ans:- **D**

$M = \int \rho dV$

$M = \int_0^{r=R_0} \frac{k}{r} 4\pi r^2 dr$

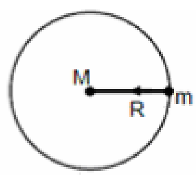
$M = \frac{4\pi k R_0^2}{2} = 2\pi k R^2$

$F_G = \frac{GMm}{R_0^2} = 2\omega_0^2 R$

$\Rightarrow \quad \frac{G\frac{4\pi k R^2}{2}}{R^2} = \omega_0^2 R \quad \Rightarrow \quad \omega_0 = \sqrt{\frac{2\pi K G}{R}}$

$\because \quad T = \frac{2\pi}{\omega_0} = \frac{2\pi\sqrt{R}}{\sqrt{2\pi K G}} = \sqrt{\frac{2\pi R}{KG}}$

$\Rightarrow \quad T^2 \propto R$



Questions: **8:-** Interference fringes are observed on a screen by illuminating two thin slits 1 mm apart with a light source (λ = 632.8 nm). The distance between the screen and the slits is 100 cm. If a bright fringe is observed on a screen at distance of 1.27 mm from the central bright fringe, then the path difference between the waves, which are reaching this point from the slits is close to:

(A) 2 nm **(B)** 2.05 μm

(C) 2.87 nm **(D)** 1.27 µm

Ans:- **D**

$\Delta P = d\sin\theta$

$= d\theta$

$= \frac{dy}{D} = \frac{10^{-3} \times 1.270 \text{ mm}}{1 \text{m}}$ 1.27 µm

***Questions*: 9:-** Consider four conducting materials copper, tungsten, mercury and aluminum with resistivity ρC, ρT, ρM and ρA respectively. Then

(A) ρA > ρT > ρC **(B)** ρM > ρA > ρC

(C) ρC > ρA > ρT **(D)** ρA > ρM > ρC

Ans:- B

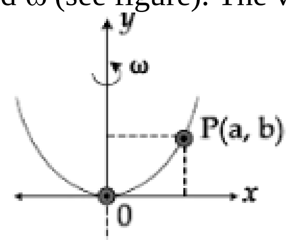
$\rho_m = 98 \times 10^{-8}$

$\rho_A = 2.65 \times 10^{-8}$

$\rho_C = 1.724 \times 10^{-8}$

$\rho_T = 5.65 \times 10^{-8}$

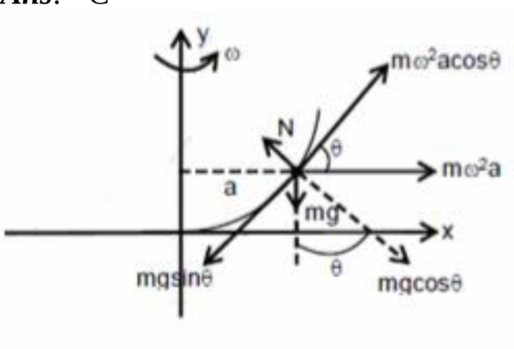
***Questions*: 10:-** A bead of mass m stays at point P (a, b) on a wire bent in the shape of a parabola y =Cx and rotating with angular speed ω (see figure). The value of ω is (neglect friction)



(A) $\sqrt{\frac{2gC}{ab}}$ **(B)** $\sqrt{\frac{2g}{C}}$

(C) $2\sqrt{2gC}$ **(D)** $2\sqrt{gC}$

Ans:- C



$m\omega^2 a\cos\theta = mg\sin\theta$

$\omega = \sqrt{\frac{g\tan\theta}{a}}$

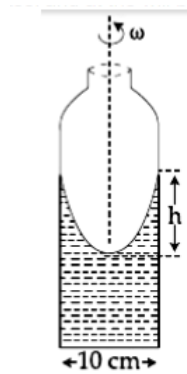
$y = 4cx^2$

$\tan\theta = \frac{dy}{dx} = 8xC$

$(\tan\theta)_{a,b} = 8aC$

$\omega = \sqrt{\frac{g \times 8ac}{a}} = 2\sqrt{2gc}$

***Questions*: 11:-** A cylindrical vessel containing a liquid is rotated about its axis so that the liquid rises at its sides as shown in the figure. The radius of vessel is 5 cm and the angular speed of rotation is ω rad s^{-1} . The difference in the height, h (in cm) of liquid at the centre of vessel and at the will be:



(A) $\frac{25\omega^2}{2g}$ **(B)** $\frac{5\omega^2}{2g}$

(C) $\frac{2\omega^2}{25g}$ **(D)** $\frac{2\omega^2}{5g}$

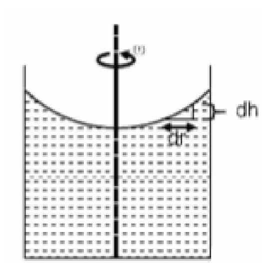
Ans:- A

$$\rho dr\omega^2 r = \rho g dh$$

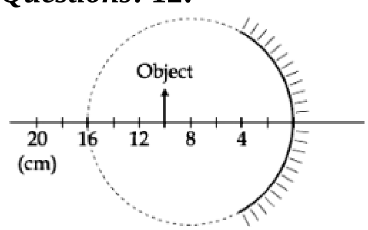
$$\omega^2 \int_0^R r dr = g \int_0^h dh$$

$$\frac{\omega^2 R^2}{2} = gh$$

$$h = \frac{\omega^2 R^2}{2g} = \frac{25\omega^2}{2g}$$



***Questions*: 12:-**

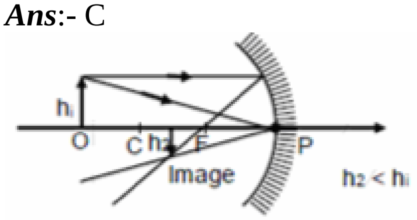


A spherical mirror is obtained as shown in the figure from a hollow glass sphere. if an object is positioned in front of the mirror, what will be the nature and magnification of the image of the object? (Figure drawn as schematic and not to scale)

(A) Inverted, real and magnified **(B)** Erect, virtual and unmagnified

(C) Inverted, real and unmagnified **(D)** Erect, virtual and magnified

Ans:- C



***Questions*: 13:-** A particle of mass m with an initial velocity $u\hat{i}$ collides perfectly elastically with a mass 3 m at rest. It moves with a velocity $v\hat{j}$ after collision, then v is given by

(A) $\upsilon = \frac{u}{\sqrt{2}}$ **(B)** $\upsilon = \frac{1}{\sqrt{6}}u$

(C) $\upsilon = \frac{u}{\sqrt{3}}$ **(D)** $\upsilon = \sqrt{\frac{2}{3}}u$

Ans:- **A**

From momentum conservation

$$mu\hat{i} + 0 = mv\hat{j} + 3m\vec{v}'$$

$$\vec{v}' = \frac{u}{3}\hat{i} - \frac{v}{3}\hat{j}$$

From kinetic energy conservation $\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + \frac{1}{2}(3\,m)\left(\left(\frac{u}{3}\right)^2 + \left(\frac{v}{3}\right)^2\right)$

Solving, $v = \frac{u}{\sqrt{2}}$

***Questions*: 14:-** If speed V, area A and force F are chosen as fundamental units, then the dimension of Young's modulus will be

(A) FA^2V^{-3} **(B)** FA^2V^{-2}

(C) FA^2V^{-1} **(D)** $FA^{-1}V^0$

Ans:- **D**

$Y \propto F^aV^bA^c$ $Y = \left(\frac{F}{A}\right)$

$$\frac{MLT^{-2}}{L^2} \propto (M^1L^1T^{-2})^a(L^1T^{-1})^b(L^2)^c$$

$$M^1L^{-1}T^{-2} \propto M^aL^{a+b+2c}\,T^{-2a-b}$$

$a + b + 2c = -1$

$-2a + b = -2$

$a = 1, b = 0, c = -1$

$Y = F^1v^0A^{-1}$

***Questions*: 15**:- An amplitude modulated wave is represented by the expression vm = 5(1 + 0.6 cos 6280t) sin (211 x 10 4t) volts. The minimum and maximum amplitudes modulated wave are respectively

(A) 3V, 5V **(B)** $\frac{3}{2}V, 5V$

(C) $\frac{5}{2}V, 8V$ **(D)** 5V, 8V

Ans:- **B**

From Given equation

$\mu = 0.6$

$A_m = \mu A_c$

$$\frac{A_{max} - A_{min}}{2} = A_c = 5 \quad \ldots(1)$$

$$\frac{A_{max} - A_{min}}{2} = 3 \quad \ldots(2)$$

From equation (1) + (2)

$A_{max} = 8$

From equation (1) – (2)

$A_{min} = 2$

***Questions*: 16:-** A gas mixture consists of 3 moles of oxygen and 5 moles of argon at temperature T. Assuming the gases to be ideal and the oxygen bond to be rigid, the total internal energy (in units of RT) of the mixture is:

(A) 15 **(B)** 20

(C) 13 **(D)** 11

***Ans*:- A**

$$\frac{f_1 n_1 RT_1}{2} + \frac{r_2 n_2 RT_2}{2} = 3 \times \frac{5}{2} RT + \frac{5}{2} \times 3RT = 15$$

***Questions*: 17:-** A beam of protons with speed 4 x 105 ms^{-1} enters a uniform magnetic field of 0.3T at an angle of 60º to the magnetic field. The pitch of the resulting helical path of protons is close to : (Mass of the proton = 1.67 x 10^{-27} kg, charge of the proton = 1.69 x 10^{-19} C)

(A) 2 cm **(B)** 4 cm

(C) 12 cm **(D)** 5 cm

***Ans*:- B**

Pitch = (V cosθ)T

$$= (V\cos\theta)\frac{2\pi m}{eB}$$

$$= (4 \times 10^5 \cos 60^\circ)\frac{2\pi}{0.3 \times 10}\left(\frac{1.67 \times 10^{-27}}{1.69 \times 10^{19}}\right)$$

= 4 cm

***Questions*: 18:-** In a reactor, 2 kg of $_{92}U^{235}$ fuel is fully used up in 30 days. The energy released per fission is 200 MeV. Given that the Avogadro number, N = 6.023 x 1026 per kilo mole and 1 eV = 1.6 x 10^{-19} J. The power output of the reactor is close to:

(A) 60 MW **(B)** 35 MW

(C) 125 MW **(D)** 54 MW

***Ans*:- A**

$$P = \frac{E}{t}$$

$$= \frac{2}{235} \times \frac{6.023 \times 10^{26} \times 200 \times 1.6 \times 10^{-19}}{30 \times 24 \times 60 \times 60} = 60 \text{ W}$$

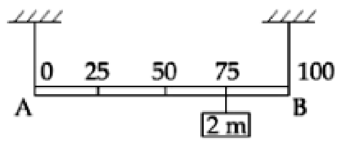
***Questions*: 19:-** 72 km/hour, respectively. A person is walking in train A in the direction opposite to its motion with a speed of 1.8 km/hour. Speed (in ms^{-1}) of this person as observed from train B will be close to : (take the distance between the tracks as negligible)

(A) 28.5 ms^{-1} **(B)** 31.5 ms^{-1}
(C) 30.5 ms^{-1} **(D)** 29.5 ms^{-1}

Ans:- **D**

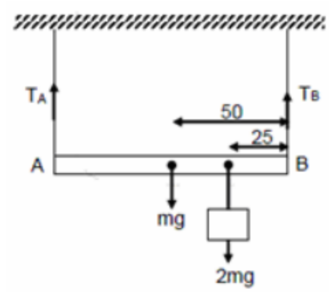
$V_A = 36$ km/hr = 10 m/s
$V_B = -72$ km/hr = –20 m/s
$V_{MA} = -1.8$ km/hr = –0.5 m/s
$V_{man, B} = V_{man, A} + V_{A, B}$
$= V_{man, A} + V_A - V_B$
$= -0.5 + 10 - (-20)$
$= -0.5 + 30 = 29.5$ m/s

Questions**: 20:-** Shown in the figure is rigid and uniform one meter long rod AB held in horizontal position by two strings tied to its ends and attached to the ceiling. The rod is of mass 'm' and has another weight of mass 2m hung at a distance of 75 cm from A. The tension in the string at A is :



(A) 0.75 mg **(B)** 1 mg
(C) 2 mg **(D)** 0.5 mg

Ans:- **B**



τ_{net} about B is zero at equilibrium
$T_A\, 100 - mg \times 50 - 2\, mg \times 25 = 0$
$T_A\, 100 = 100$ mg
$T_A = 1$ mg