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JEE MAIN 2019_(PHYSICS) CHALLENGE PAPER & SOLUTIONS

PHYSICS

|JEE MAIN 2019 | DATE : 09 JANUARY 2019 (SHIFT-1) MORNING

1. A conducting circular loop made of a thin wire has area $3.5 \times 10^{-3} m^2$ and resistance 10Ω. It is placed perpendicular to a time dependent magnetic field B(t) = (0.4 T) sin (50 πt). The field is uniform in space. Then the net charge is uniform in space. Then the net charge flowing through the loop during t = 0 s and t = 10 ms is close to :

(1) 7 mC (2) 21 mC (3) 14 mC (4) 7 mC

ANS. (BONUS)

Sol. $Q = \frac{\Delta\phi}{R}, \Delta\phi = \int_0^{t=10ms} BAdt$

$$\Delta\phi = \int_0^{t=10ms} 0.4\sin(50\pi t) \times 3.5 \times 10^{-3} dt = 1.4 \times 10^{-3}$$

$$Q = \frac{1.4 \times 10^{-3}}{10} = 140\mu C$$

No option matched so it should be bonus.

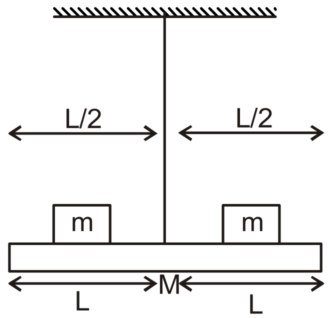
|JEE MAIN 2019 | DATE : 09 JANUARY 2019 (SHIFT-2) EVENING

18. A rod of mass 'M' and length '2L' is suspended at its middle by a wire. It exhibits torsional oscillations; If two masses each of 'm' are attached at distance 'L/2' from its centre on both sides, it reduces the oscillation frequency by 20%. The value of ratio m/M is close to :

(1) 0.17 (2) 0.57 (3) 0.77 (4) 0.37

Ans. (4)

Sol.



$$f_0 = \frac{1}{2\pi}\sqrt{\frac{c}{I_0}}$$

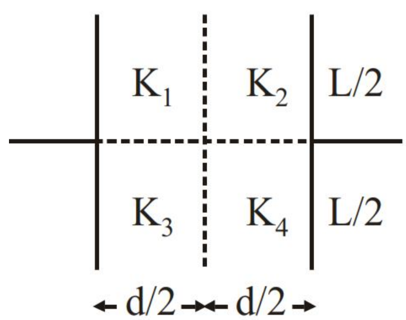
$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3c}{ML^2}}$$

$$I' = \frac{ML^2}{3} + \frac{2.mL^2}{4}$$

$$f' = \frac{1}{2\pi}\sqrt{\frac{C}{L^2\left(\frac{M}{3}+\frac{m}{2}\right)}} = 0.8\,f_0$$

$$\frac{m}{M} = \frac{3}{8} = 0.37$$

21. A parallel plate capacitor with square plates is filled with four dielectrics of dielectric constants K_1, K_2, K_3, K_4 arranged as shown in the figure. The effective dielectric constant K will be :



(1) $K = \frac{(K_1+K_2)(K_3+K_4)}{2(K_1+K_2+K_3+K_4)}$

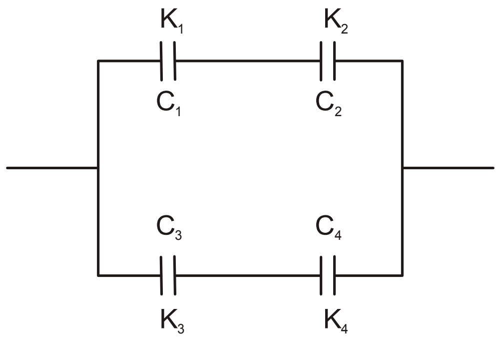
(2) $K = \frac{(K_1+K_4)(K_2+K_3)}{2(K_1+K_2+K_3+K_4)}$

(3) $K = \frac{(K_1+K_3)(K_2+K_3)}{K_1+K_2+K_3+K_4}$

(4) $K = \frac{(K_1+K_2)(K_3+K_4)}{K_1+K_2+K_3+K_4}$

Ans.

Sol.



$$C_{eq.} = \frac{C_1C_2}{C_1+C_2} + \frac{C_3C_4}{C_3+C_4} \equiv K_{eq.}\frac{A\varepsilon_0}{d}$$

$$K_{eq.} = \frac{K_1K_2}{K_1+K_2} + \frac{K_3K_4}{K_3+K_4}$$

29. The pitch and the number of divisions, on the circular scale, for a given screw gauge are 0.5 mm and 100 respectively. When the screw gauge is fully tightened without any object, the zero of its circular scale lies 3 divisions below the mean line.

The readings of the main scale and the circular scale, for a thin sheet, are 5.5 mm and 48 respectively, the thickness of this sheet is :

(1) 5.755 mm (2) 5.725 mm (3) 5.740 mm (4) 5.950 mm

Ans. (1)

Sol. Pitch = 0.5 mm

$$\text{L. C.} = \frac{0.5}{100}\text{mm}$$

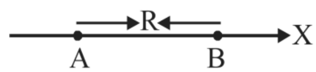
Actual

reading $= 5.5\text{mm} + (48+3) \times 5 \times 10^{-3}\,\text{m}$

$= 5.755$ mm

|JEE MAIN 2019 | DATE : 10 JANUARY 2019 (SHIFT-1) MORNING

16. Two electric dipoles, A, B with respective dipole moments $\vec{d}_A = -4qa\hat{i}$ and $\vec{d}_B = -2qa\hat{i}$ are placed on the x-axis with a separation R, as shown in the figure

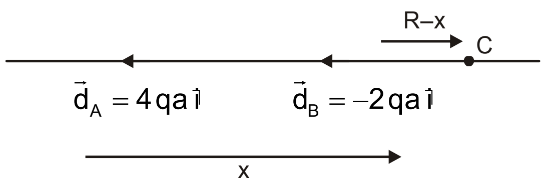


The distance from A at which both of them produce the same potential is :

(1) $\frac{\sqrt{2}R}{\sqrt{2}-1}$ (2) $\frac{R}{\sqrt{2}-1}$ (3) $\frac{R}{\sqrt{2}+1}$ (4) $\frac{\sqrt{2}R}{\sqrt{2}+1}$

Ans. (1)

Sol.



$V_1 = V_2$

$\Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{4qa\cos 80^o}{x^2} = \frac{1}{4\pi\varepsilon_0}\frac{2qa\cos 80^o}{(R-x)^2}$

$\Rightarrow \sqrt{2}(R-x) = \pm x$

$\Rightarrow \sqrt{2}R = (\sqrt{2}\pm 1)x$

$\therefore x = \frac{\sqrt{2}R}{\sqrt{2}\pm 1}R$

As x > R

$\therefore x = \frac{\sqrt{2}R}{\sqrt{2}-1}$

|JEE MAIN 2019 | DATE : 10 JANUARY 2019 (SHIFT-2) EVENING

17. Consider the nuclear fission

$Ne^{20} \rightarrow 2He^{4} + C^{12}$

Given that the binding energy/nucleon of Ne^{20}, He^{4} and C^{12} are, respectively, 8.03 MeV, 7.07 MeV and 7.86 MeV, identify the correct statement :

(1) 8.3 MeV energy will be released
(2) energy of 11.9 MeV has to be supplied
(3) energy of 12.4 MeV will supplied
(4) energy of 3.6 MeV will be released

Ans. (2)

Sol. Q = BE of product – BE of reactant

$= 8 \times 7.07 + 12 \times 7.86 - 20 \times 8.03$

$= 56.56 + 94.32 - 160.6$

$Q = -9.72$ (endothermic)

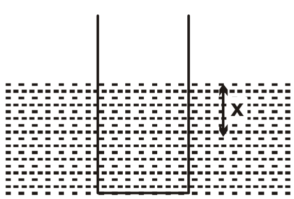
24. A cylindrical plastic bottle of negligible mass is filled with 310 ml of water and left floating in a pond with still water. If pressed downward slightly and released, it starts performing simple harmonic motion at angular frequency ω. If the radius of the bottle is 2.5 cm then ω close to :

(density of water = 10^3 kg/m^3)

(1) 3.75 rad s^{-1}
(2) 1.25 rad s^{-1}
(3) 5.00 rad s^{-1}
(4) 2.50 rad s^{-1}

Ans. (BONUS)

Sol.



Unbalanced force

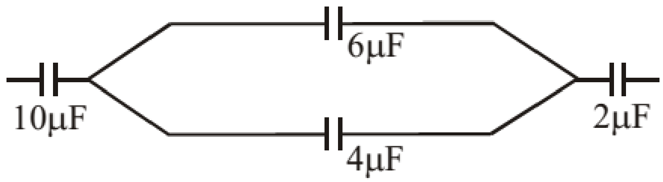
$-\pi r^2 x \rho g = m\ddot{x}$

$\ddot{x} = -\frac{-\pi r^2 \rho g}{m} x$

$\omega = \sqrt{\frac{\pi r^2 \rho g}{m}} \approx 7.8$

|JEE MAIN 2019 | DATE : 11 JANUARY 2019 (SHIFT-1) MORNING

10. In the figure shown below, the charge on the left plate of the 10μF capacitor is –30μC. The charge on the right plate of the 6 μF capacitor is :



(1) +12 μC

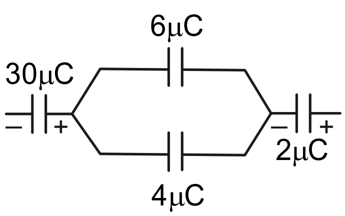
(2) –18 μC

(3) +18 μC

(4) –12 μC

Ans. (3)

Sol.



$6\mu F$ and $4\mu F$ are in parallel and total charge on this combination is $30\mu C$

Charge on $6\mu F$ capacitor $= \frac{6}{6+4} \times 30$

$= 18\mu C$

Since charge is asked on right plate there fore is $+18\mu C$

19. A body of mass 1 kg falls freely from a height of 100 m on a platform of mass 3 kg which is mounted on a spring having spring constant k = 1.25 × 10^6 N/m. The body sticks to the platform and the spring's maximum compression is found to be x. Given that g = 10 ms^{-2}, the value of x will be close to :

(1) 4 cm

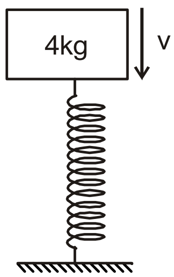
(2) 80 cm

(3) 40 cm

(4) 8 cm

Ans. (1)

Sol.



Velocity of 1kg block just before collides with 3 kg block $=\sqrt{2hg}=\sqrt{2000}\ \text{m/s}$

Apply momentum conservation just before and just after collision

$1\times\sqrt{2000}=4v \Rightarrow v=\dfrac{\sqrt{2000}}{4}\text{m/s}$

Initial compression of spring

1.25×10^{6} , $x_0=30 \Rightarrow x_0=0$

Applying work energy theorem

$\rightarrow 40\times x+\dfrac{1}{2}\times125\times10^{6}\left(0^2-x^2\right)$

$=0-\dfrac{1}{2}\times4v^2$

Solving $x\simeq 4\text{cm}$

|JEE MAIN 2019 | DATE : 11 JANUARY 2019 (SHIFT-2) EVENING

7. A simple pendulum of length 1 m is oscillating with an angular frequency 10 rad/s. The support of the pendulum starts oscillating up and down with a small angular frequency of 1 rad/s and an amplitude of 10^{-2} m. The relative change in the angular frequency of the pendulum is best given by:-

(1) 10^{-3}rad/s

(2) 10^{-1}rad/s

(3) 1 rad/s

(4) 10^{-5}rad/s

Ans. (Bonus)

Sol.

9. The region between y = 0 and y = d contains a magnetic field $\vec{B} = B\hat{z}$. A particle of mass m and charge q enters the region with a velocity $\vec{v} = v\hat{i}$. If $d = \frac{mv}{2qB}$, the acceleration of the charged particle at the point of its emergence at the other side is :

(1) $\frac{qvB}{m}\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(2) $\frac{qvB}{m}\left(\frac{1}{2}\hat{i}-\frac{\sqrt{3}}{2}\hat{j}\right)$

(3) $\frac{qvB}{m}\left(\frac{-\hat{j}+\hat{i}}{\sqrt{2}}\right)$

(4) $\frac{qvB}{m}\left(\frac{\sqrt{3}}{2}\hat{i}+\frac{1}{2}\hat{j}\right)$

Ans. (Bonus)

Sol.

24. A pendulum is executing simple harmonic motion and its maximum kinetic energy is K_1. If the length of the pendulum is doubled and it performs simple harmonic motion with the same amplitude as in the first case, its maximum kinetic energy is K_2. Then :-

(1) $K_2 = \frac{K_1}{4}$

(2) $K_2 = \frac{K_1}{2}$

(3) $K_2 = K_1$

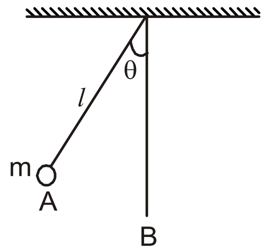
(4) $K_2 = 2K_1$

Ans. (D)

Sol. Maximum kinetic energy at lowest point B is given by

$$K = mg\ell\,(1-\cos\theta)$$

Where $\theta =$ angular amplitude



$K_1 = mg\ell\,(1-\cos\theta)$

$K_2 = mg\,(2\ell)\,(1-\cos\theta)$

$K_2 = 2K_1$

27. A copper wire is wound on a wooden frame, whose shape is that of an equilateral triangle. If the linear dimension of each side of the frame is increased by a factor of 3, keeping the number of turns of the coil per unit length of the frame the same, then the self inductance of the coil :

(1) decreases by a factor of 9

(2) decreases by a factor of $9\sqrt{3}$

(3) increases by a factor of 27

(4) increases by a factor of 3

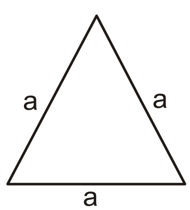
Ans. (D)

Sol. Total length L will remain constant

$L = (3a)\,N$ (N = total turns)

And length of winding = (d) N

(d = diameter of wire)



Self inductance = $\mu_0 n^2 A\ell$

$= \mu_0 n^2 \left(\frac{\sqrt{3}\,a^2}{4}\right) dN$

$\propto a^2 N \propto a$

So self inductance will become 3 times

|JEE MAIN 2019 | DATE : 12 JANUARY 2019 (SHIFT-2) EVENING

9. When a certain photosensistive surface is illuminated with monochromatic light of frequency v, the stopping potential for the photo current is $-V_0/2$. When the surface is illuminated by monochromatic light of frequency v/2, the stopping potential is $-V_0$. The threshold frequency for photoelectric emission is :

(1) 2v (2) $\frac{4}{3}v$ (3) $\frac{3v}{2}$ (4) $\frac{5v}{3}$

Ans. (Bonus)

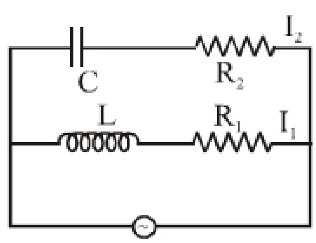
Sol. $e\frac{V_0}{2} = hv - \phi$ ...(i)

$eV_0 = \frac{hv}{2} - \phi$ ...(ii)

$\Rightarrow 2eV_0 = \left(\frac{eV_0}{2} + \phi\right) - 2\phi$

$\Rightarrow \phi = \frac{-3eV_0}{2}$

17. In the above circuit, $C = \frac{\sqrt{3}}{2}\mu F$, $R_2 = 20\Omega$, $L = \frac{\sqrt{3}}{10}H$ and $R_1 = 10\Omega$. Current in L-R_1 path is I_1 and in C-R_2 path it is I_2. The voltage of A.C source is given by, $V = 200\sqrt{2}\sin(100t)$ volt. The phase difference between I_1 and I_2 is :



(1) 30° (2) 60° (3) 90° (4) 0°

Ans.(Bonus)

Sol. $Z_C = \frac{1}{100 \times \frac{\sqrt{3}}{2} \times 10^{-6}} = \frac{2 \times 10^4}{\sqrt{3}}$

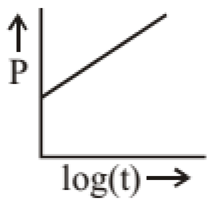
$Z_L = \frac{\sqrt{3}}{10} \times 150 = 10\sqrt{3}$

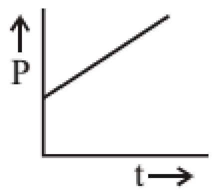
$\tan\phi_2 = \frac{Z_C}{R_2} = \frac{2 \times 10^4}{\sqrt{3} \times 20} = \frac{10^3}{\sqrt{3}}$

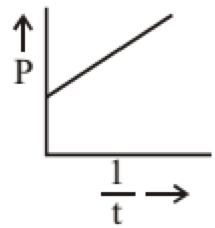
$$\tan\phi_1 = \frac{Z_L}{R_1} = \frac{10\sqrt{3}}{10} = \sqrt{3}$$

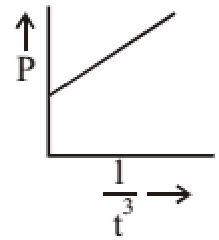
$$\phi_1 = 60^\circ$$

28. A soap bubble, blown by a mechanical pump at the mouth of a tube, increases in volume, with time, at a constant rate. The graph that correctly depicts the time dependence of pressure inside the bubble is given by :

(1) 

(2) 

(3) 

(4) 

Ans. (4)

Sol. $V = \frac{4}{3}\pi r^3$

$$\frac{dV}{dt} = \left(4\pi r^2\right)\frac{dr}{dt}$$

$$\Rightarrow r^2\frac{dr}{dt} = K$$

$$\Rightarrow \frac{r^3}{3} = Kt$$

$$r \propto t^{1/3}$$

Now, $P = P_0 + \frac{4s}{r}$

$$P = P_0 + \frac{4s}{t^{1/3}}$$