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JEE MAIN 2023

JAN ATTEMPT

PAPER-1 (B.Tech / B.E.)

QUESTIONS & SOLUTIONS

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1 FEBRUARY, 2023

9:00 AM to 12:00 Noon

Duration : 3 Hours | Maximum Marks : 300

SUBJECT - PHYSICS

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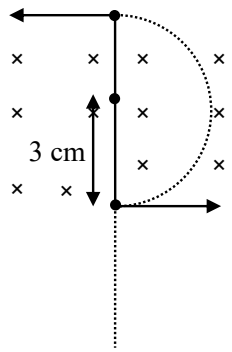
PHYSICS

1. A charged particle of charge 2μC is accelerated through potential difference of 100 V and then passed through a uniform magnetic field of strength 4mT which is perpendicular to plane of velocity. If the charged particle moves in a circle of radius 3 cm, the mass of the particle is $N \times 10^{-18}$ Kg. Find the value of N.

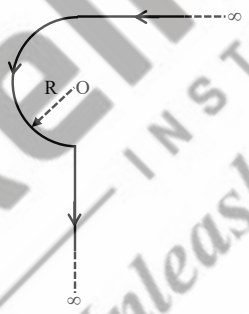
Ans. **144**

Sol. $r = \frac{mv}{qB} = \frac{\sqrt{2km}}{qB}, m = \frac{r^2q^2B^2}{2k}$



$$m = \frac{\frac{3}{100} \times \frac{3}{100} \times 2 \times 2 \times 4 \times 10^{-3} \times 4 \times 10^{-3} \times 10^{-12}}{2 \times (100)^2 \times 10^{-6}} = 144 \times 10^{-18} \text{ kg}$$

2. The magnetic field at point O in the figure shown is



(1) $\frac{\mu_0 I}{4\pi R}(\pi+2)$ (2) $\frac{\mu_0 I}{4R}(\pi+1)$ (3) $\frac{\mu_0 I}{4\pi R}(\pi+1)$ (4) $\frac{\mu_0 I}{4R}(\pi+2)$

Ans. **(3)**

Sol. $B_0 = \left(\frac{\mu_0 I}{4R} + \frac{\mu_0 I}{4\pi R}\right) = \frac{\mu_0 I}{4\pi R}(\pi+1)$

3. The de-Broglie wavelengths of a Proton and an Alpha particle are same. If the velocity of proton is $\frac{c}{10}$. The ratio of kinetic energy of Proton to kinetic energy of the Alpha particle is :

(1) 1 : 2 (2) 2 : 1 (3) 4 : 1 (4) 1 : 4

Ans. **(3)**

Sol. $\lambda = \frac{h}{\frac{mc}{10}} = \frac{h}{4mv'}$

$v' = \frac{c}{40}$

$\frac{KE_p}{KE_\alpha} = \frac{\frac{1}{2}m\left(\frac{c}{10}\right)^2}{\frac{1}{2}4m\left(\frac{c}{40}\right)^2} = 4:1$

4. A particle is performing SHM about origin with amplitude 3 cm. Find the value of displacement (in cm) from mean position where kinetic energy is 25% more than the potential energy of the system.

Ans. **2**

Sol. K.E = 1.25 P.E.

$\frac{1}{2}m\omega^2(A^2 - x^2) = 1.25\ \frac{1}{2}\ kx^2$

$A^2 - x^2 = x^2 \times \frac{5}{4}$

$A^2 = \frac{9}{4}x^2$

$x = \frac{2A}{3} = 2$ cm

5. A 5kg block is at rest on rough horizontal surface. A force of 30N starts acting on it horizontally. In 10 seconds its displacement is 50m. Find the coefficient of friction between the block and the surface.

Ans. **0.5**

Sol. $F - \mu mg = ma$

$S = ut + ut + \frac{1}{2}at^2$

$50 = 0 + \frac{1}{2} \times a \times 100$

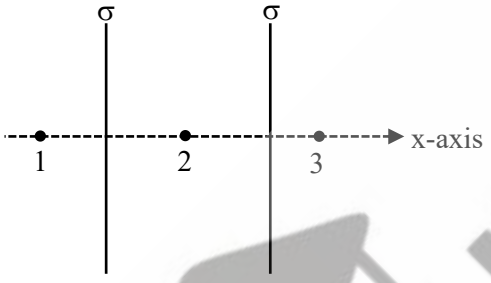
$a = 1\ m/s^2$

$30 - \mu \times 50 = 5 \times 1$

$50\mu = 25$

$\mu = \frac{1}{2}$

6. Two non-conducting sheets having charge density σ on each plate are shown in figure. Sheets are parallel to yz plane. The Electric field at point 1,2,3 respectively are :



(1) $\frac{-\sigma}{\varepsilon_0}\hat{i}, 0, \frac{\sigma\hat{i}}{\varepsilon_0}$ (2) $\frac{\sigma}{\varepsilon_0}\hat{i}, 0, \frac{\sigma}{\varepsilon_0}\hat{i}$ (3) $\frac{\sigma}{\varepsilon_0}\hat{i}, 0, \frac{-\sigma}{\varepsilon_0}\hat{i}$ (4) $\frac{-\sigma\hat{i}}{\varepsilon_0}, \frac{\sigma\hat{i}}{\varepsilon_0}, \frac{\sigma\hat{i}}{\varepsilon_0}$

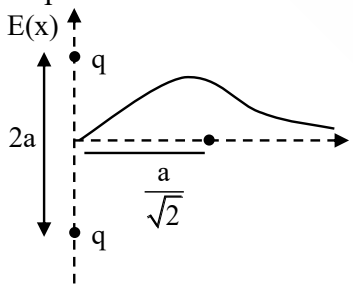
Ans. **(1)**

Sol. P

7. Two identical charged particles are placed at a distance 2a from each other. The force exerted by the two charges on a point charge kept on the perpendicular bisector is maximum at distance $\frac{a}{\sqrt{x}}$ from the midpoint of the line joining the two charges. Find x.

Ans. **2**

Sol. Graph of electric field



Field is maximum at $\frac{a}{\sqrt{2}}$.

Hence x = 2

8. Consider a planet whose mass is $\frac{1}{9}$th of mass of earth and radius of planet is half of earth's radius. If escape speed on the surface of planet is $V_e\frac{\sqrt{x}}{3}$ where V_e is escape speed on earth's surface, then chose the correct value of x :

(1) 18 (2) 2 (3) 1 (4) 3

Ans. **(2)**

Sol. $V_{(escape)planet} = \sqrt{\frac{2GM_P}{R_P}}$

$= \sqrt{\frac{2G\left(\frac{M_e}{9}\right)}{\left(\frac{R_e}{2}\right)}} = \frac{V_e\sqrt{2}}{3} \quad \therefore \quad x = 2$

9. A body travels with uniform speed V_1, V_2, V_3 in the region AB, BC and CD respectively. If AB = BC and AD = 3 AB the average speed for the complete motion is

(1) $\frac{3v_1v_2v_3}{v_1v_2+v_2v_3+v_3v_1}$ (2) $\frac{v_1v_2v_3}{v_1v_2+v_2v_3+v_3v_1}$ (3) $\frac{v_1v_2v_3}{3(v_1v_2+v_2v_3+v_3v_1)}$ (4) None of these

Ans. **(1)**

Sol. AB = x

BC = x

2x + CD = 3x

CD = x

$\langle v\rangle = \frac{3x}{\frac{x}{v_1}+\frac{x}{v_2}+\frac{x}{v_3}} = \frac{3v_1v_2v_3}{v_2v_3+v_1v_3+v_1v_2}$

10. The tension in the string of linear mass density 7×10^{-3} kg/m is 70 N. Speed of wave of the string is $x \times 10^2$ m/s. Find x.

Ans. **(x = 1)**

Sol. $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{70}{70\times10^{-3}}} = 1 \times 10^2$ m/s

x = 1

11. A solid cylinder is released from rest from top of a incline of length 60 cm of inclination 30°. Find speed of cylinder when it reaches bottom of incline, assuming it performs pure rolling [$g = 10m/s^2$]

Ans. **2**

Sol. Applying C.O.M.E

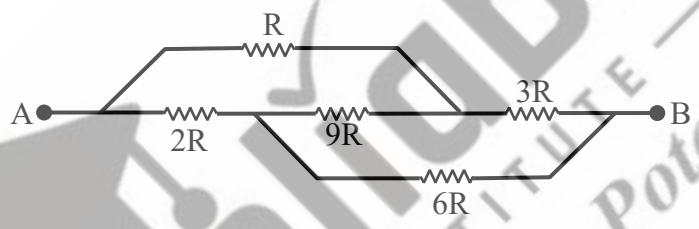
$$Mgh\sin30° = \frac{1}{2}mv^2 + \frac{1}{2}\frac{mR^2}{2}\omega^2$$

$$\frac{gh}{2} = \frac{v^2}{2} + \frac{v^2}{4} = \frac{3v^2}{4}$$

$$\frac{10\times0.6\times2}{3} = v^2$$

$$v = 2m/s$$

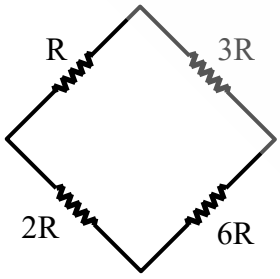
12. Find the equivalent resistance between A & B.



(1) $\frac{8}{3}R$ (2) 14 R (3) $\frac{2R}{3}$ (4) 21 R

Ans. **(1)**

Sol. Wheat stone bridge is in balanced condition.



$$\frac{1}{R_{eq}} = \frac{1}{4R} + \frac{1}{8R}$$

$$R_{eq} = \frac{8R}{3}$$

13. If adiabatic constant of ideal gas is $\frac{3}{2}$. If gas having number of moles 'n' expand adiabatically from volume v to 2 v and change in temp is –T. Find the work done by gas.

(1) 3 nRT (2) 2 nRT (3) 4 nRT (4) – nRT

Ans. **(2)**

Sol. $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$

$W = \frac{nR(\Delta T)}{\gamma - 1} = \frac{nR(T_i - T_f)}{\gamma - 1}$

$W = \frac{-nR(-T)}{\frac{3}{2} - 1}$ $\{T_f - T_i = -T\}$

$W = +2\ nRT$

14. Match the column I with II

Column - I	**Column - II**
(A) Intrinsic semiconductor	(p) Fermi level near conduction band.
(B) n-type semiconductor	(q) Fermi level at middle
(C) p-type semiconductor	(r) Fermi level near valence band
(D) Metal	(s) Fermi level inside conduction band

(1) (A) $\rightarrow$ q, (B) $\rightarrow$ p, (C) $\rightarrow$ r, (D) $\rightarrow$ s (2) (A) $\rightarrow$ p, (B) $\rightarrow$ q, (C) $\rightarrow$ r, (D) $\rightarrow$ s

(3) (A) $\rightarrow$ r, (B) $\rightarrow$ p, (C) $\rightarrow$ q, (D) $\rightarrow$ s (4) (A) $\rightarrow$ s, (B) $\rightarrow$ p, (C) $\rightarrow$ r, (D) $\rightarrow$ q

Ans. **(1)**

Sol. Based on theory.

15. Which of the following frequency is not suitable for FM ?

(1) 68 MHz (2) 88 MHz (3) 99 MHz (4) 108 MHz

Ans. **(1)**

Sol. FM broadcast range is 88MHz to 108MHz

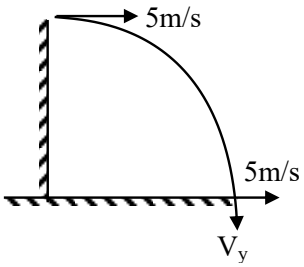
16. A projectile is thrown horizontally with speed of 5m/s from a tower of height 10m. Find speed of particle just before it hits the ground : [$g = 10m/s^2$]

(1) 15 m/s (2) 5 m/s (3) 20 m/s (4) 10 m/s

Ans. **(1)**

Sol. $t = \sqrt{\frac{2h}{g}} = \sqrt{2}$ (t is time to fall on ground)

$V_y = 0 + g \times \sqrt{2}$



$V_y = 10\sqrt{2} m/s$

$V_{net} = \sqrt{5^2 + 200} = 15 m/s$

17. In potentiometer balance length is 60 cm for cell of e.m.f 1.5 volt. When this cell is replaced by another cell of e.m.f $\varepsilon_2 = \frac{x}{10}$ volt, balance length is increased by 40 cm, then the value of x is

Ans. **25**

Sol. $\frac{\varepsilon_1}{\varepsilon_2} = \frac{\ell_1}{\ell_2}$

$\frac{1.5}{\varepsilon_2} = \frac{60}{60+40} = \frac{6}{10} = \frac{3}{5}$

$\varepsilon_2 = \frac{5}{2} = \frac{x}{10}$

$x = 25$

18. A drop of radius 10^{-3} m having surface tension S = 0.45 N/m gets break into 125 drops. Find increase in its surface energy ?

(1) 15.3×10^{-6} J (2) 25.3×10^{-6} J (3) 22.6×10^{-6} J (4) 10^{-6} J

Ans. **(3)**

Sol. Initial surface energy = $0.45 \times 4\pi (10^{-3})^2$

& $\frac{4}{3}\pi(10^{-3})^3 = 125 \times \frac{4\pi}{3} R_{new}^3$

$\therefore\ 10^{-3} = 5\ R_{new}$

$\therefore\ R_{new} = \frac{10^{-3}}{5}$ m

So, final surface energy = $0.45 \times 125 \times 4\pi \left(\frac{10^{-3}}{5}\right)^2$

Increase in energy = $0.45 \times 4\pi \times (10^{-3})^2 \left[\frac{125}{25} - 1\right]$

$= 4 \times 0.45 \times 4\pi \times 10^{-6}$

$= 22.6 \times 10^{-6}$ J

19. Average translational kinetic energy of an ideal gas molecule depends on which of the following.

(1) Nature of gas (2) Temperature of gas

(3) Volume of gas (4) Pressure of gas

Ans. **(2)**

Sol. Basic theory

Translational K.E on average of a molecule is $\frac{3}{2}$KT which is independent of nature, pressure and volume.

20. Vanderwall equation of a gas is given as $\left(P + \frac{a}{b^2}\right)(v - b) = nRT$. Dimension of $\left(\frac{b^2}{a}\right)$ matches with?

(1) Modulus of rigidity (2) Bulk modulus

(3) Compressibility (4) Volume stress

Ans. **(3)**

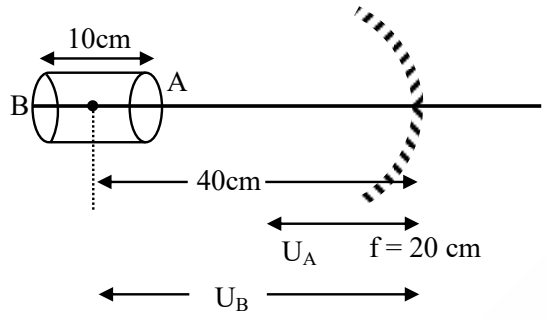
Sol. $\left[\frac{a}{b^2}\right] = [P]$

$\therefore\quad \left[\frac{b^2}{a}\right] = \frac{1}{[P]} = \frac{1}{[B]} = [K]$

21. A cylindrical wire of length 10 cm is placed along principle axis of concave mirror of focal length 20 cm. The mid-point of the wire is at a distance 40 cm from pole. Find length of image.

Ans. **10.67 cm**

Sol. $U_A = 35$ cm $\qquad \frac{1}{V}+\frac{1}{U}=\frac{1}{f}$



$U_B = 45$ cm $\qquad \frac{1}{V_A}+\frac{1}{-35}=\frac{1}{-20} \quad \Rightarrow \quad V_A=\frac{-140}{3}$ cm

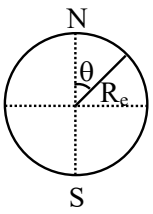
$\frac{1}{V_B}+\frac{1}{-45}=\frac{1}{-20} \quad \Rightarrow \quad V_B=-36$ cm

Length of image $= V_B - V_A = -36-\left(\frac{-140}{3}\right)=\frac{32}{3}\text{cm}=10.67\text{cm}$

22. An unpolarised light of intensity I_0 is incident on polariser system in which the successive transmission axis are at an angle 45º. Find the number of polarisers, if final intensity is $\frac{I_0}{64}$.

Ans. **6**

Sol. $I_1=\frac{I_0}{2}, \qquad I_2=\frac{I_0}{2}\cos^2 45^\circ=\frac{I_0}{4}=\frac{I_0}{2^2}$



$R_e \rightarrow$ radius of earth

$I_N=\frac{I_0}{64}=\frac{I_0}{2^6}$

$N = 6$

23. **Statement-1 :** Acceleration due to gravity is different at different places on earth's surface.
Statement-2 : Acceleration due to gravity increases below earth's surface.
(1) Statement 1 is true, statement 2 is true
(2) Statement 1 is false, statement 2 is false
(3) Statement 1 is false, statement 2 is true
(4) Statement 1 is true, statement 2 is false

Ans. **(4)**

Sol. $g_{eff} = g - \omega^2 R_e \sin^2\theta$
$\theta \rightarrow$ co-latitude angle
$d \rightarrow$ depth
$g_{eff} = g\left(1 - \frac{d}{R_e}\right)$

24. Match the list-I with list-II.

List-I	**List-II**
(P) AC Generator	(1) Presence of L & C
(Q) Resonance phenomena	(2) Q-factor
(R) Sharpness of resonance curve	(3) Mutual Inductance
(S) Transformer	(4) EMI

Choose the correct option :
(1) P→4, Q→1, R→ 2, S→ 3
(2) P→1, Q→4, R→ 3, S→ 3
(3) P→2, Q→3, R→ 1, S→ 4
(4) P→4, Q→2, R→ 1, S→ 3

Ans. **(1)**

25. Find Binding energy of Helium from given data:-
M_p=1.007276 amu
m_N = 1.008665 amu
m_{He} = 4.002603 amu
(1) 48 MeV (2) 12 MeV (3) 26 MeV (4) 40 MeV

Ans. **(3)**

Sol. B.E of Helium = $(2m_P + 2m_N - m_{He} + 2m_e)c^2$
= 26 MeV

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