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

JEE (Main) 2021

Question & Solutions

(Reproduced from memory retention)

Date : 24 February, 2021 (SHIFT-2) Time ; (3.00 pm to 6.00 pm)

Duration : 3 Hours | Max. Marks : 300

SUBJECT : PHYSICS

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PHYSICS

1. Which of the following is correct for zener diode

(1) Lightly dopped, depletion layer thickness is less

(2) Heavily dopped, depletion layer thickness is less

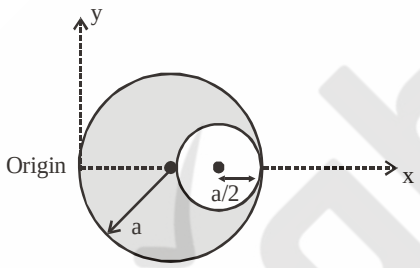
(3) Lightly dopped, depletion layer thickness is more

(4) Heavily dopped, depletion layer thickness is more.

Ans. **(4)**

Sol. It is heavily dopped and work in reverse biased so depletion layer thickness is more.

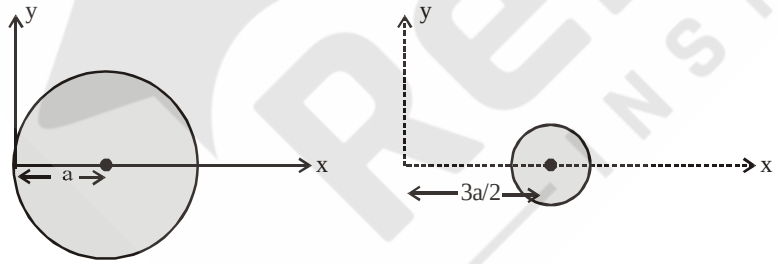
2. Disc of radius $\frac{a}{2}$ is cut from disc of radius a. Find x-co-ordinate of COM from origin.



(1) $\frac{5a}{6}$ (2) $\frac{a}{6}$ (3) $\frac{a}{3}$ (4) $\frac{a}{2}$

Ans. **(1)**

Sol.



$$x_{com} = \frac{(\sigma \times \pi a^2 \times a) - \sigma\pi \frac{a^2}{4} \times 3\frac{a}{2}}{\sigma\pi a^2 - \sigma\frac{\pi a^2}{4}}$$

$$X_{com} = \frac{a - \frac{3a}{8}}{1 - \frac{1}{4}} = \frac{\frac{5a}{8}}{\frac{3}{4}} = \frac{5a}{6}$$

3. A body is projected from origin with a velocity v_0 along +ve x-axis on which a force $-\alpha x^2$ is acting on it. Find the maximum distance from origin up to which the body can go. (x is the position of particle).

(1) $\left(\frac{3mv_0^2}{2\alpha}\right)^{\frac{1}{3}}$ (2) $\left(\frac{3mv_0^2}{2\alpha}\right)^{\frac{1}{2}}$ (3) $\left(\frac{2mv_0^2}{3\alpha}\right)^{\frac{1}{3}}$ (4) $\left(\frac{2mv_0^2}{3\alpha}\right)^{\frac{1}{2}}$

Ans. **(1)**

Sol. $F = -\alpha x^2 = ma$

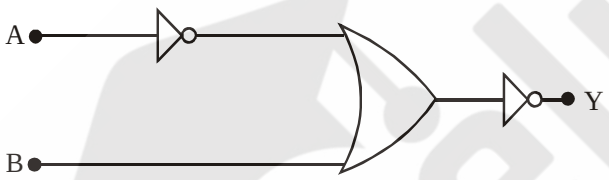
$$a = \frac{-\alpha x^2}{m} = v\frac{dv}{dx}$$

$$\int_{v_0}^{0} v dv = \int_0^x -\frac{\alpha x^2 dx}{m}$$

$$-\frac{v_0^2}{2} = -\frac{\alpha x^3}{3m}$$

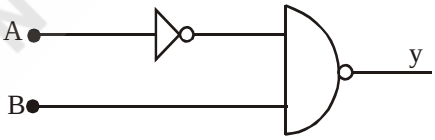
$$x = \left(\frac{3mv_0^2}{2\alpha}\right)^{\frac{1}{3}}$$

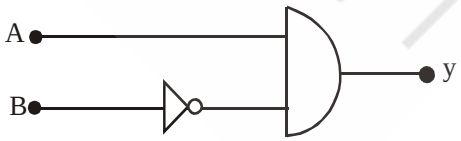
4.

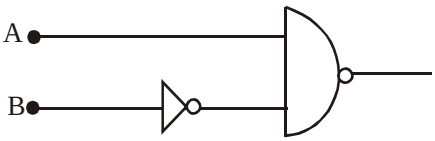


This diagram is equivalent to

(1)


(2)


(3)


(4)


Ans. **(3)**

Sol. $y = \overline{\overline{A} + B} = A\overline{B}$

which is equivalent to (3) option

5. Weight at pole is 49 Newton then then weight at equator?

(1) 48.83 N (2) 49.17 N (3) 49.83 N (4) 49 N

Ans. (1)

Sol. $mg = 49$

$m(g - \omega^2 R)$ will be less than mg.

6. If the de-Broglie wavelengths of α-particle and proton are equal then the ratio of their velocities are

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

Ans. **(1)**

Sol. $$\frac{h}{m_\alpha v_\alpha} = \frac{h}{m_p v_p}$$

$$\Rightarrow \frac{u_\alpha}{u_p} = \frac{m_p}{m_\alpha} = \frac{1}{4}$$

7. A light source emitting light and if we change light from violet to red then

(1) Fringes become dark

(2) The separation between two consecutive fringes decreases

(3) Intensity of central maxima will increase

(4) Intensity of central maxima will decrease

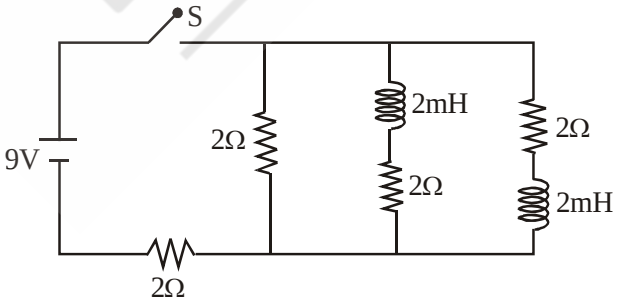
Ans. (1)

Sol. $\beta = \frac{\lambda D}{d}$, $\lambda_V < \lambda_R$

$\beta_V < \beta_R$

There is no change in intensity of bright and dark fringes.

8. Switch S is closed at t = 0. Find the current given by battery just after closing the switch:

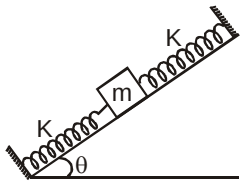


(1) 2.25 A (2) 3.36 A (3) zero (4) 4.5 A

Ans. **(1)**

Sol. $i = \frac{9}{4} A = 2.25$ A

9. Find frequency of oscillation of spring block system shown.



(1) $\frac{1}{2\pi}\sqrt{\frac{2K}{m}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{4K}{m}}$ (3) $\frac{1}{2\pi}\sqrt{\frac{6K}{m}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{K}{2m}}$

Ans. (1)

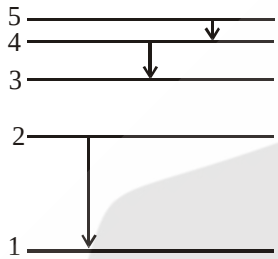
Sol. $T = 2\pi\sqrt{\frac{m}{2K}} \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{2K}{m}}$

10. For which of the following transitions in Hydrogen-like atom of the frequency of emitted photon will be maximum

(1) n = 2 to n = 1 (2) n = 4 to n = 3 (3) n = 5 to n = 4 (4) n = 3 to n = 2

Ans. **(1)**

Sol.



$\boxed{\Delta E = hf}$

f is more for transitions from n = 2 to n = 1

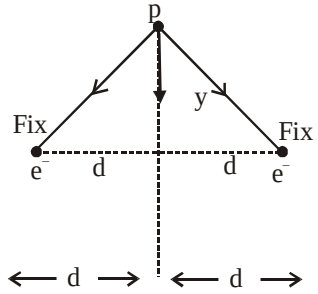
11. Two electron are fix, at separation 2d. At middle of these two charges a proton is free to oscillate. Mass of proton is m_p and charge of proton is e.

Now if proton is slightly displaced perpendicular to line joining of charge then find it's angular frequency of oscillation.

(1) $\sqrt{\frac{e^2}{2\pi\epsilon_0 m_p d^3}}$ (2) $\sqrt{\frac{2e^2}{\pi\epsilon_0 d^2 m_p}}$ (3) $\sqrt{\frac{2e^2\epsilon_0 m_p}{\pi d^2}}$ (4) $\sqrt{\frac{2\epsilon_0 e^2 m_p}{\pi d^2}}$

Ans. **(1)**

Sol.



Restoring force on proton

$$F_r = \frac{2Ke^2y}{(d^2+y^2)^{3/2}} \qquad y <<<<< d$$

$$F_r = \frac{2Ke^2y}{d^3} = \frac{e^2y}{2\pi \in_0 d^3} = ky$$

$$k = \frac{e^2}{2\pi \in_0 d^3}$$

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{e^2}{2\pi \in_0 md^3}}$$

12. If soft iron (ferromagnetic substance) is placed in external uniform magnetic field.

(1) Size of domain will change and orientation also change.

(2) Size of domain will increase

(3) Size of domain will decrease

(4) Does not depend on external magnetic field.

Ans. **(1)**

Sol. **Theoretical**

13. Which of the following represent travelling wave?

(1) $y = A \sin (15\ t - 2x)$

(2) $y = A \cos (15\ t) \sin 2x$

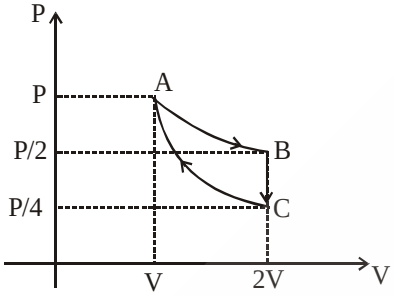
(3) $y = A \sin (15\ t) \cos 2x$

(4) $y = A\ e^{-x} \cos (15\ t - 2x)$

Ans. **(1)**

Sol. travelling wave function is $f(t \pm x/v)$

14. P-V diagram is shown. AB is Isothermal process and during AB temperature is T. Gas is 1 mole, BC is isochoric and CA is adiabatic process. Coefficient of adiabatic exponent is γ . Find total work done by gas.



(1) $RT\left[\ln 2-\frac{1}{2(\gamma-1)}\right]$

(2) RT ln2

(3) $\frac{RT}{2(\gamma-1)}$

(4) zero

Ans. **(1)**

Sol. $W_{AB} = nRT \ln 2 = RT\ln 2$

$W_{BC} = 0$

$$W_{CA} = \frac{PV-\frac{P}{4}\times 2V}{1-\gamma} = \frac{PV}{2(1-\gamma)}$$

$$W_{ABCA} = RT \ln 2 + \frac{RT}{2(1-\gamma)}$$

$$RT\left[\ln 2-\frac{1}{2(\gamma-1)}\right]$$

15. Which of the following are correctly matches.

(A) x-ray	(i) Inter electron transition
(B) γ-ray	(ii) Vibration of atom and molecule
(C) Radio-wave	(iii) radioactivity
(D) Micro-wave	(iv) LASER
	(v) Magnetron
	(vi) Rapid acceleration and deceleration of electron in aerials

(1) (A) $\rightarrow$ (i), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (vi), (D) $\rightarrow$ (v)

(2) (A) $\rightarrow$ (ii), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (vi), (D) $\rightarrow$ (i)

(3) (A) $\rightarrow$ (i), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (vi)

(4) (A) $\rightarrow$ (v), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (vi), (D) $\rightarrow$ (ii)

Ans. **(1)**

Sol. Theoretical information based

16. Time period of simple pendulum is given by $T = 2\pi\sqrt{\frac{\ell}{g}}$.

Find % error in g when T is 1.95 sec and ℓ = 1 meter.

Given least count in ℓ = 1mm and least count in T = 10 milli second, find percentage error in g

(1) 2.2% (2) 1.33% (3) 1.12% (4) 1.03%

Ans. (3)

Sol. $T^2 = 4\pi^2\left[\frac{\ell}{g}\right]$

$g = 4\pi^2\left[\frac{\ell}{T^2}\right]$

$\frac{\Delta g}{g} = \frac{\Delta\ell}{\ell} + \frac{2\Delta T}{T}$

$= \left[\frac{1mm}{1m} + \frac{2(10\times10^{-3})}{1.95}\right]\times100$

= 1.12 %

17. In x-ray tube experiment accelerating voltage is given by 1.24 M volt. Find cut of wavelength.

(1) 10^{-3} nm (2) 10^{-2} nm (3) 10^{-4} nm (4) 10^{-5} nm

Ans. **(1)**

Sol. $\lambda_{min} = \frac{\lambda c}{ev} = \frac{1240nm - ev}{1.24\times10^6}$

$\lambda_{min} = 10^{-3}$ nm

18. Read the given statement

S-1 A transistor can be made by using two P-N diode connected in series.

S-2 β is ratio of $\frac{I_C}{I_B}$

(1) S-1 is true, S-2 is false

(2) S-1 is false, S-2 is true

(3) S-1 is true, S-2 is true

(4) S-1 is false, S-2 is false

Ans. (2)

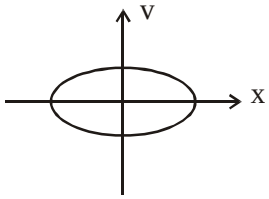
Sol. Theoretically

19. Which of the following curve represents relation between velocity with displacement of particle performing simple harmonic motion

(1) ellipe (2) circle (3) hyperbola (4) straight line

Ans. **(1)**

Sol. $v = \omega\sqrt{A^2 - x^2}$



20. Which of the following is most appropriate regarding Bohr model.

(A) speed $\propto \frac{Z}{n}$ (B) frequency of oscillation $\propto \frac{Z^3}{n^3}$

(C) coulombic force of attraction $\propto \frac{Z^3}{n^4}$ (D) Kinetic Energy $\propto \frac{Z^2}{n^2}$

(1) A,C,D (2) A,B,D (3) B,D (4) A,B

Ans. **(1)**

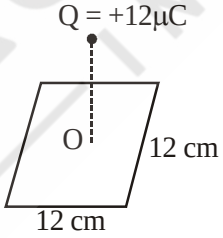
Sol. Speed $\propto \frac{Z}{n}$

frequency of oscillation $\propto \frac{Z^2}{n^3}$

coulombic force of attraction $\propto \frac{Z^3}{n^4}$

Kinetic Energy $\propto \frac{Z^2}{n^2}$

21. A point charge Q = 12 μC at distance 6 cm from centre of square of side 12cm as shown in figure. Electric flux through square is $x \times 10^3$ S.I. units. Find x.



Ans. **226**

Sol. using gues law it is a part of cube of side 12 cm and charge at centre so $\Phi = \frac{Q}{6\varepsilon_0} = \frac{12\mu C}{6\varepsilon_0}$

$x \times 10^3 = 2 \times 4\pi \times 9 \times 10^9 \times 10^{-6}$

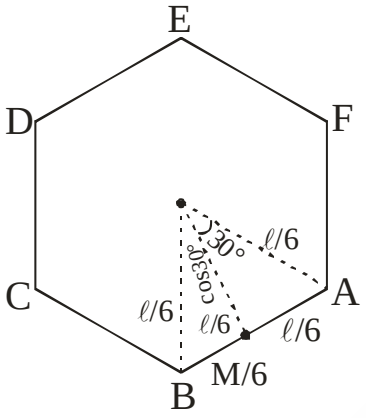
$\Phi = 72\ \pi \times 10^3$ SI units

$x = 226$

22. A rod of length 2.4 m and mass 6 kg is bent to form a regular hexagon. Find the moment of inertia (kgm^2) of the hexagon about the axis perpendicular to the plane of hexagon passing through its centre.

Ans. 0.8

Sol.



$$I_{AB} = \left[\frac{M}{6}\left(\frac{\ell}{6}\right)^2}{12} + \frac{M}{6}\left(\frac{\ell}{6}\frac{\sqrt{3}}{2}\right)^2\right]$$

$$I_{hexagon} = 6I_{AB} = M\left[\frac{\ell^2}{12\times 36} + \frac{\ell^2}{36}\times\frac{3}{4}\right]$$

$$= \frac{6}{100}\left[\frac{24\times 24}{12\times 36} + \frac{24\times 24}{36}\times\frac{3}{4}\right]$$

$$= \frac{1}{100}[80] = 0.8\ kgm^2$$

23. Two objects of mass ratio 1 : 2 have ratio of kinetic energy A : 1. If their momentum are same find A?

Ans. **2**

Sol. $\frac{M_1}{M_2} = \frac{1}{2}$

$M_1V_1 = M_2V_2 = P$

$K_1 = \frac{P^2}{2M_1}$ $\qquad$ $K_2 = \frac{P^2}{2M_2}$

$\frac{K_1}{K_2} = \frac{M_2}{M_1} = \frac{2}{1}$

$= \frac{A}{1} = \frac{2}{1} = \mathbf{2}$

24. Two cars A and B both are moving towards each other with a speed of 7.2 km/hr. Source A produces a sound of frequency 676 Hz. Find the beat frequency (Hz) heard by the person sitting in car A. (speed of sound is 340 m/sec in air)

Ans. **16**

Sol. frq. observed by A = $f_A = 676$ Hz

frq. observed by B = $f_B = \left(\frac{v+u}{v-u}\right)f$

frq. observed by A after reflection from B is

$$f_A' = \left(\frac{v+u}{v-u}\right)f_B = \left(\frac{v+u}{v-u}\right)^2 f$$

Beats frq. : $f_b = f_A' - f_A = \left[\left(\frac{v+u}{v-u}\right)-1\right]f$

$$= \left[\frac{v^2+u^2+2uv-v^2-u^2+2uv}{(v-u)^2}\right]f$$

$$= \frac{4uv}{(v-u)}\times f \qquad v >>> u$$

$$= \left(\frac{4uv}{v^2}\right)f = \frac{4u}{v}\times f = 4\times\frac{2}{340}\times 676\text{Hz} = 16\text{Hz}$$

25. On applying force to a rod along its length, the rod gets elongated by 0.04m. If the length of rod is doubled and diameter is also doubled and same force is applied along the length and it is found that the rod gets elongated by $x \times 10^{-2}$ m. Find the value of x.

Ans. 2

Sol.

$$\frac{F}{A} = y\frac{\Delta L}{L}$$

$$\frac{F}{A} = y \times \frac{0.04}{L} \qquad \ldots(i)$$

$$\frac{F}{4A} = y\times\frac{\Delta L}{2L} \qquad \ldots(ii)$$

$$4 = \frac{0.04\times 2}{\Delta L}$$

$\Delta L = 2 \times 10^{-2}$

$x = 2$

26. There is a cylindrical wire radius 0.5 mm and conductance $5 \times 10^7\ \Omega m^{-1}$, If the potential gradient along the length of cylindrical wire is 10 mV/m and the current flowing through cylindrical wire is $x^3 \times \pi$ mA. Find the value of x.

Ans. **5**

Sol. $J = \sigma E$

$= 5 \times 10^7 \times 10 \times 10^{-3}$

$= 50 \times 10^4$ A/m^2

$I = J\pi R^2$

$= 50 \times 10^4 \times \pi (0.5 \times 10^{-3})^2$

$= 50 \times 10^4 \times \pi \times 0.25 \times 10^{-6}$

$= 125 \times 10^{-3}\ \pi$

$x = 5$

27. In series LCR circuit at resonance power consumption in circuit is 16W if voltage source of frequency 10^5 rad/s is 120 V then find resistance (Ω) of circuit.

Ans. **800**

Sol. $\frac{(120)^2}{R} = 16$

$R = \frac{14400}{16} = 800\ \Omega$

28. A gas is at rms speed 200 m/sec at 27°C and 1 atm pressure. If it's rms speed is $\frac{x}{\sqrt{3}}$ m/s when temp is 127°C and 2 atm pressure, find value of x

Ans. 400

Sol. $V_{rms} = \sqrt{\frac{3RT}{M_0}}$

$200 = \sqrt{\frac{3R \times 300}{M_0}}$

$\frac{x}{\sqrt{3}} = \sqrt{\frac{3R \times 400}{M_0}}$

$\frac{200}{\frac{x}{\sqrt{3}}} = \sqrt{\frac{3}{4}}$

$\frac{200\sqrt{3}}{x} = \frac{\sqrt{3}}{2}$

$X = 400$ m/s

29. **Coming soon**

Ans. **( )**

Sol. (

30. **Coming soon**

Ans. **( )**

Sol. (