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

JEE (Main) 2021

Question & Solutions

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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JEE-MAIN 2021 (24 FEBRUARY ATTEMPT) SHIFT-2

PHYSICS

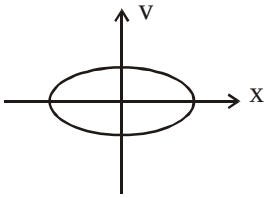
1. When a particle executes SHM, the nature of graphical representation of velocity as a function of displacement is :

(1) circular (2) elliptical

(3) parabolic (4) straight line

Official Ans. by NTA (2)

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

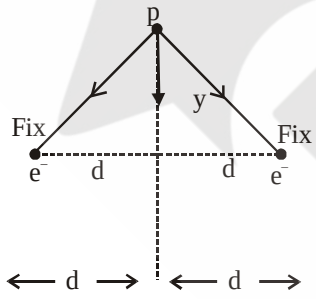


2. Two electrons each are fixed at a distance '2d'. A third charge proton placed at the midpoint is displaced slightly by a distance x (x << d) perpendicular to the line joining the two fixed charges. Proton will execute simple harmonic motion having angular frequency : (m = mass of charged particle)

(1) $\left(\frac{2q^2}{\pi\varepsilon_0 md^3}\right)^{\frac{1}{2}}$ (2) $\left(\frac{\pi\varepsilon_0 md^3}{2q^2}\right)^{\frac{1}{2}}$ (3) $\left(\frac{q^2}{2\pi\varepsilon_0 md^3}\right)^{\frac{1}{2}}$ (4) $\left(\frac{2\pi\varepsilon_0 md^3}{q^2}\right)^{\frac{1}{2}}$

Official Ans. by NTA (3)

Sol.



Restoring force on proton

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

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

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

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

3. On the basis of kinetic theory of gases, the gas exerts pressure because its molecules :

(1) continuously lose their energy till it reaches wall.

(2) are attracted by the walls of container.

(3) continuously stick to the walls of container.

(4) suffer change in momentum when impinge on the walls of container.

Official Ans. by NTA (4)

Sol. Basic Theory

4. A soft ferromagnetic material is placed in an external magnetic field. The magnetic domains :

(1) increase in size but no change in orientation.

(2) have no relation with external magnetic field.

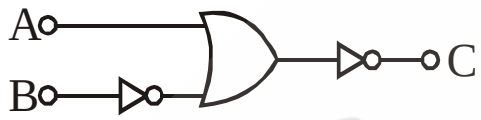
(3) decrease in size and changes orientation.

(4) may increase or decrease in size and change its orientation.

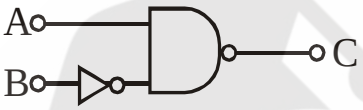
Official Ans. by NTA (4)

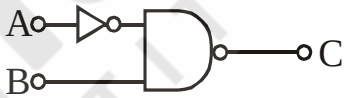
Sol. Basic Theory

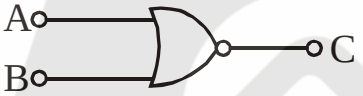
5.



The logic circuit shown above is equivalent to :

(1)


(2)


(3)


(4)


Official Ans. by NTA (4)

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

$y = \overline{A} \cdot B$

6. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of 'L' is 1.0 m from meter scale having a minimum division of 1 mm and time of one complete oscillation is 1.95 s measured from stopwatch of 0.01 s resolution. The percentage error in the determination of 'g' will be :

(1) 1.13%

(2) 1.03%

(3) 1.33%

(4) 1.30%

Official Ans. by NTA (1)

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

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

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

$= \left[\frac{1mm}{1m} + \frac{2(10\times10^{-3})}{1.95}\right]\times 100$

$= 1.13\ \%$

7. Given below are two statements :

Statement I : PN junction diodes can be used to function as transistor, simply by connecting two diodes, back to back, which acts as the base terminal.

Statement II : In the study of transistor, the amplification factor β indicates ratio of the collector current to the base current.

In the light of the above statements, choose the correct answer from the options given below :

(1) Statement I is false but Statement II is true

(2) Both Statement I and Statement II are true

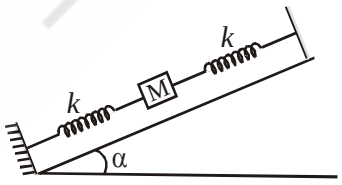
(3) Both Statement I and Statement II are false

(4) Statement I is true but Statement II is false

Official Ans. by NTA (1)

Sol. Basic Theory

8. In the given figure, a body of mass M is held between two massless springs, on a smooth inclined plane. The free ends of the springs are attached to firm supports. If each spring has spring constant *k*, the frequency of oscillation of given body is :

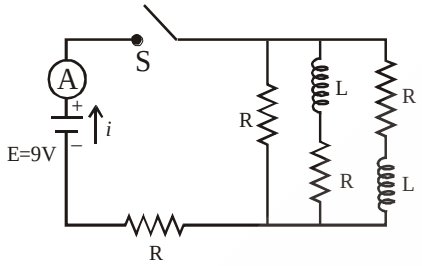


(1) $\frac{1}{2\pi}\sqrt{\frac{k}{2M}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{2k}{Mg\sin\alpha}}$ (3) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{k}{Mg\sin\alpha}}$

Official Ans. by NTA (3)

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

9. Figure shows a circuit that contains four identical resistors with resistance R = 2.0 Ω, two identical inductors with inductance L = 2.0 mH and an ideal battery with *emf* E = 9 V. The current '*i*' just after the switch 'S' is closed will be :



(1) 2.25 A (2) 3.0 A (3) 3.37 A (4) 9 A

Official Ans. by NTA (1)

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

10. The de Broglie wavelength of a proton and α-particle are equal. The ratio of their velocities is :

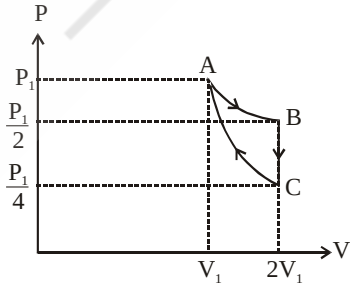
(1) 4 : 3 (2) 4 : 1 (3) 4 : 2 (4) 1 : 4

Official Ans. by NTA (2)

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

$\Rightarrow \frac{v_\alpha}{v_p} = \frac{m_p}{m_\alpha} = \frac{1}{4}$

11. If one mole of an ideal gas at (P_1, V_1) is allowed to expand reversibly and isothermally (A to B) its pressure is reduced to one-half of the original pressure (see figure). This is followed by a constant volume cooling till its pressure is reduced to one-fourth of the initial value (B→C). Then it is restored to its initial state by a reversible adiabatic compression (C to A). The net workdone by the gas is equal to :



(1) $RT\left(\ln 2 - \frac{1}{2(\gamma-1)}\right)$ (2) $-\frac{RT}{2(\gamma-1)}$ (3) 0 (4) RT ln 2

Official Ans. by NTA (1)

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

$W_{BC} = 0$

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

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

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

12. An X-ray tube is operated at 1.24 million volt. The shortest wavelength of the produced photon will be :

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

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

Official Ans. by NTA (1)

Sol. $\lambda_{min} = \frac{\lambda c}{ev} = \frac{1240nm - ev}{1.24 \times 10^6}$

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

13. Which of the following equations represents a travelling wave ?

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

(2) $y = Ae^{-x^2}(vt + \theta)$

(3) $y = Ae^{x}\cos(\omega t - \theta)$

(4) $y = A\sin x \cos\omega t$

Official Ans. by NTA (1)

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

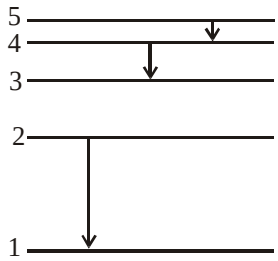
14. According to Bohr atom model, in which of the following transitions will the frequency be maximum ?

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

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

Official Ans. by NTA (2)

Sol.



$\boxed{\Delta E = hf}$

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

15. If the source of light used in a Young's double slit experiment is changed from red to violet :

(1) consecutive fringe lines will come closer.

(2) the central bright fringe will become a dark fringe.

(3) the fringes will become brighter .

(4) the intensity of minima will increase.

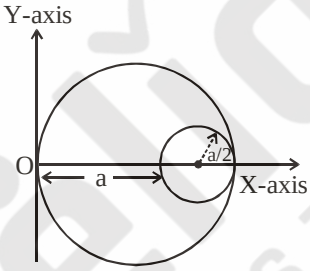
Official Ans. by NTA (1)

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.

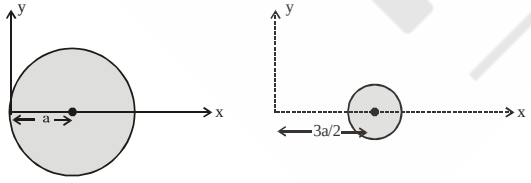
16. A circular hole of radius $\left(\frac{a}{2}\right)$ is cut out of a circular disc of radius 'a' as shown in figure. The centroid of the remaining circular portion with respect to point 'O' will be :



(1) $\frac{1}{6}a$ (2) $\frac{10}{11}a$ (3) $\frac{5}{6}a$ (4) $\frac{2}{3}a$

Official Ans. by NTA (3)

Sol.



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

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

17. Zener breakdown occurs in a *p-n* junction having p and n both :

(1) lightly doped and have wide depletion layer.

(2) heavily doped and have narrow depletion layer.

(3) lightly doped and have narrow depletion layer.

(4) heavily doped and have wide depletion layer.

Official Ans. by NTA (2)

18. Match List - I with List - II.

List - I	**List - II**
(a) Source of microwave frequency	(i) Radioactive decay of nucleus
(b) Source of infrared frequency	(ii) Magnetron
(c) Source of Gamma Ray electrons	(iii) Inner shell
(d) Source of X-rays	(iv) Vibration of atoms and molecules
	(v) LASER
	(vi) RC circuit

Choose the correct answer from the options given below :

(1) (a)-(vi), (b)-(iv), (c)-(i), (d)-(v)

(2) (a)-(vi), (b)-(v), (c)-(i), (d)-(iv)

(3) (a)-(ii), (b)-(iv), (c)-(vi), (d)-(iii)

(4) (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

Official Ans. by NTA (4)

Sol. Theoretical information based

19. A particle is projected with velocity v_0 along x-axis. A damping force is acting on the particle which is proportional to the square of the distance from the origin i.e., $ma = -\alpha x^2$. The distance at which the particle stops :

(1) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{2}}$ (2) $\left(\frac{2v_0}{3\alpha}\right)^{\frac{1}{3}}$ (3) $\left(\frac{2v_0^2}{3\alpha}\right)^{\frac{1}{2}}$ (4) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{3}}$

Official Ans. by NTA (4)

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

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

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

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

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

20. A body weighs 49 N on a spring balance at the north pole. What will be its weight recorded on the same weighing machine, if it is shifted to the equator ?

(Use $g = \frac{GM}{R^2} = 9.8\ ms^{-2}$ and radius of earth, R = 6400 km.]

(1) 49 N (2) 48.83 N

(3) 49.83 N (4) 49.17 N

Official Ans. by NTA (2)

Sol. $mg = 49$

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

21. A uniform metallic wire is elongated by 0.04 m when subjected to a linear force F. The elongation, if its length and diameter is doubled and subjected to the same force will be _____ cm.

Official Ans. by NTA 2

Sol.

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

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

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

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

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

$$x = 2$$

22. A cylindrical wire of radius 0.5 mm and conductivity 5×10^7 S/m is subjected to an electric field of 10 mV/m. The expected value of current in the wire will be $x^3\pi$ mA. The value of x is ____.

Official Ans. by NTA 5

Sol. $J = \sigma E$

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

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

$I = J\pi R^2$

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

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

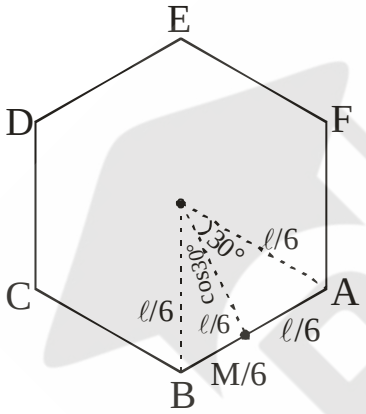
$= 125 \times 10^{-3}\ \pi$

$x = 5$

23. A uniform thin bar of mass 6 kg and length 2.4 meter is bent to make an equilateral hexagon. The moment of inertia about an axis passing through the centre of mass and perpendicular to the plane of hexagon is ____ $\times 10^{-1}$ kg m^2.

Official Ans. by NTA 8

Sol.



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

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

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

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

24. Two solids A and B of mass 1 kg and 2 kg respectively are moving with equal linear momentum. The ratio of their kinetic energies $(K.E.)_A : (K.E.)_B$ will be $\frac{A}{1}$, so the value of A will be ___.

Official Ans. by NTA 2

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

$M_1V_1 = M_2V_2 = P$

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

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

25. The root mean square speed of molecules of a given mass of a gas at 27°C and 1 atmosphere pressure is 200 ms^{-1}. The root mean square speed of molecules of the gas at 127°C and 2 atmosphere pressure is $\frac{x}{\sqrt{3}} ms^{-1}$. The value of x will be _____.

Official Ans. by NTA 400

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

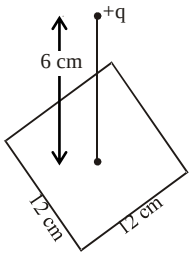
$200 = \sqrt{\frac{3R \times 300}{M_0}}$

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

$\frac{200}{\frac{X}{\sqrt{3}}} = \sqrt{\frac{3}{4}}; \frac{200\sqrt{3}}{x} = \frac{\sqrt{3}}{2}$

$X = 400$ m/s

26. A point charge of +12 μC is at a distance 6 cm vertically above the centre of a square of side 12 cm as shown in figure. The magnitude of the electric flux through the square will be _____ × 10^3 Nm^2/C.



Official Ans. by NTA 226

Sol. using Gauss' 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

$x = 226$

27. A signal of 0.1 kW is transmitted in a cable. The attenuation of cable is –5 dB per km and cable length is 20 km. The power received at receiver is 10^{-x} W. The value of x is _____.

[Gain in dB = $10 \log_{10}\left(\frac{P_0}{P_i}\right)$]

Official Ans. by NTA 8

Sol. Sound level decreases by 5dB every km so sound level decreased in 20 km = 100 dB

$\beta_2 - \beta_1 = 10 \log_{10} \frac{I_2}{I_1}$

$-100 = 10 \log_{10} \frac{I_2}{I_1} \Rightarrow \frac{I_1}{I_2} = 10^{10}$

$I_2 = 10^{-10}\, I_1 \Rightarrow P_2 = 10^{-10}\, P_1 = 10^{-8}$ W

$x = 8$

28. A series LCR circuit is designed to resonate at an angular frequency $\omega_0 = 10^5$ rad/s. The circuit draws 16 W power from 120 V source at resonance. The value of resistance 'R' in the circuit is ___Ω.

Official Ans. by NTA 900

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

$R = \frac{14400}{16} = 900\,\Omega$

29. Two cars are approaching each other at an equal speed of 7.2 km/hr. When they see each other, both blow horns having frequency of 676 Hz. The beat frequency heard by each driver will be _____ Hz. [Velocity of sound in air is 340 m/s.]

Official Ans. by NTA 8

Sol. frq. observed by A coming from produced by A = 676 Hz = f_A

frq. observed by A coming from B for the wave generated by B = $f_B = \left(\frac{v+u}{v-u}\right) f = 684$ Hz.

Beats frq. : $f_b = f_B' - f_A = 8\text{Hz}$

30. An electromagnetic wave of frequency 3 GHz enters a dielectric medium of relative electric permittivity 2.25 from vacuum. The wavelength of this wave in that medium will be ____ $\times 10^{-2}$ cm.

Official Ans. by NTA 667

Sol. λ in vacuum $= \frac{c}{f} = \frac{3\times10^8}{3\times10^9} = 0.1\text{m}$

$\therefore$ λ in medium $= \frac{0.1}{\mu}$

Where refractive index

$$\mu = \sqrt{\mu_r \varepsilon_r}$$

Assuming non-magnetic material $\mu_r = 1$

$\therefore$ $\mu = \sqrt{2.25} = 1.5$

$\lambda_m = \frac{0.1}{1.5} = \frac{1}{15}\text{m} = 6.67\text{m}$

$= 667 \times 10^{-2}$ cm

Ans. 667