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JEE (Main)

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

2023

COMPUTER BASED TEST (CBT)
Questions & Solutions

Date: 06 April, 2023 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

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PART : PHYSICS

31. The number of air molecules per cm^3 increased from 3×10^{19} to 12×10^{19}. The ratio of collision frequency of air molecule before and after the increase in number respectively is:

(1) 0.75 (2) 1.25 (3) 0.25 (4) 0.50

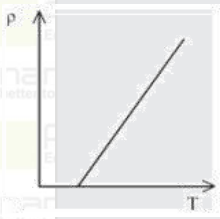
NTA Ans. (3)

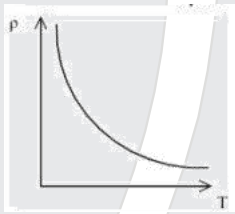
Reso Ans. (3)

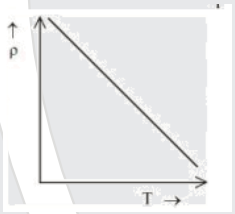
Sol. $f \propto N$

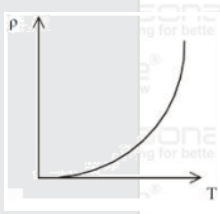
$$\frac{f_1}{f_2} = \frac{N_1}{N_2} = \frac{3\times10^{19}}{12\times10^{19}} = \frac{1}{4} = 0.25$$

32. The resistivity (ρ) of semiconductor varies with temperature. Which of the following curve represents the correct behaviour

(1) 

(2) 

(3) 

(4) 

NTA Ans. (2)

Reso Ans. (2)

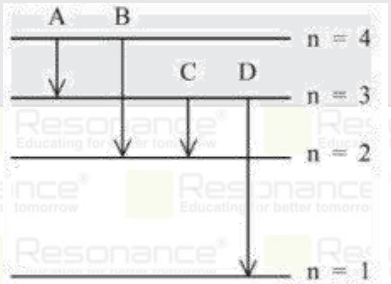
33. For the plane electromagnetic wave given by $E = E_o \sin(\omega t - kx)$ and $B = B_o \sin(\omega t - kx)$, the ratio of average electric energy density to average magnetic energy density is

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

NTA Ans. (3)

Reso Ans. (3)

34. The energy levels of an hydrogen atom are shown below. The transition corresponding to emission of shortest wavelength is



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

NTA Ans. (1)

Reso Ans. (1)

35. Two resistance are given as $R_1 = (10 \pm 0.5)\ \Omega$ and $R_2 = (15 \pm 0.5)\ \Omega$. The percentage error in the measurement of equivalent resistance when they are connected in parallel is :

(1) 6.33 (2) 5.33 (3) 2.33 (4) 4.33

NTA Ans. (4)

Reso Ans. (4)

Sol. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R} = \frac{1}{15} + \frac{1}{10}$

$R = 6\Omega$

$\frac{\Delta R}{R^2} = \left[\frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}\right]$

$\Delta R = R^2\left[\frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}\right] = 6^2\left[\frac{0.5}{15^2} + \frac{0.5}{10^2}\right] = 36\,[0.0022 + 0.005] = \frac{975}{225} = 4.33\,\Omega$

36. By what percentage will the transmission range of a TV tower be affected when the height of the tower is increased by 21%?

(1) 10% (2) 12% (3) 15% (4) 14%

NTA Ans. (1)

Reso Ans. (1)

Sol. $d = \sqrt{2RH}$

$d' = \sqrt{2R \times 1.21H}$

$\frac{d'-d}{d} \times 100 = 10\%$

37. A small ball of mass M and density ρ is dropped in a viscous liquid of density ρ_o. After some time, the ball falls with a constant velocity. What is the viscous force on the ball?

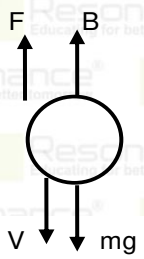
(1) $F = Mg\left(1+\frac{\rho_o}{\rho}\right)$ (2) $F = Mg\left(1+\frac{\rho}{\rho_o}\right)$ (3) $F = Mg\left(1-\frac{\rho_o}{\rho}\right)$ (4) $F = Mg\,(1 \pm \rho\rho_o)$

NTA Ans. (3)

Reso Ans. (3)

Sol. $F = mg - B$

$= mg - \frac{m}{\rho} \times \rho_0 g = mg\left(1-\frac{\rho_0}{\rho}\right)$



38. A small block of mass 100g is tied to a spring of spring constant 7.5 N/m and length 20 cm. The other end of spring is fixed at a particular point A. If the block moves in a circular path on a smooth horizontal surface with constant angular velocity 5 rad/s about point A, then tension in the spring is –

(1) 1.5 N (2) 0.75 N (3) 0.50 N (4) 0.25 N

NTA Ans. (2)

Reso Ans. (2)

Sol. $T = m\omega^2(\ell + x) = kx$

$$\frac{m\omega^2\ell}{k - m\omega^2} = x$$

$T = kx$

$$T = \frac{m\omega^2\ell \times k}{k - m\omega^2}$$

$$= \frac{0.1(5)^2(.20)\times 7.5}{7.5 - 0.1(5^2)} = \frac{25\times 7.5\times 2\times 10^{-2}}{5} = .75$$

39. A source supplies heat to a system at the rate of 1000 W. If the system performs work at a rate of 200 W. The rate at which internal energy of the system increases is.

(1) 500 W (2) 1200 W (3) 800 W (4) 600 W

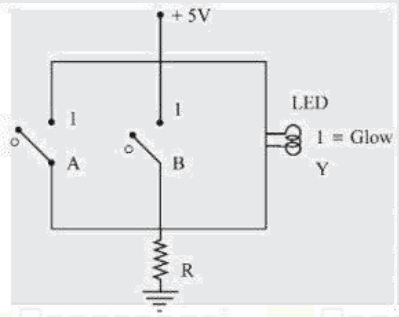
NTA Ans. (3)

Reso Ans. (3)

Sol. $1000 = 200 + \Delta U$

$\Delta U = 800$ W

40. Name the logic gate equivalent to the diagram attached



(1) AND (2) NAND (3) NOR (4) OR

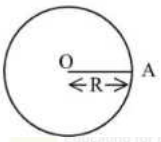
NTA Ans. (3)

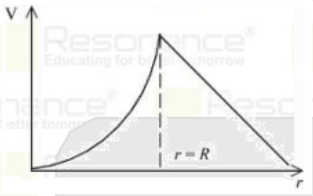
Reso Ans. (3)

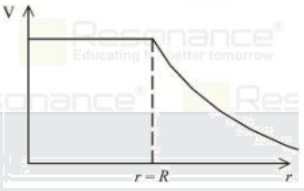
Sol. NOR

A	B	Output
1	0	0
0	1	0
1	1	0

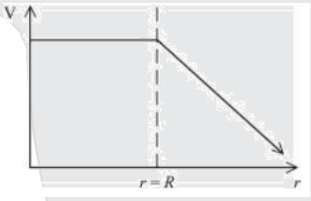
41. For a uniformly charged thin spherical shell, the electric potential (V) radially away from the centre (O) of shell can be graphically represented as–



(1) 

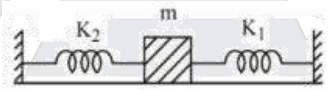
(2) 

(3) 

(4) 

NTA Ans. (2)
Reso Ans. (2)

42. A mass m is attached to two strings as shown in figure. The spring constant of two springs are K_1 and K_2. For the frictionless surface, the time period of oscillation of mass m is.



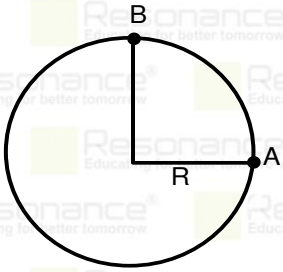
(1) $2\pi\sqrt{\frac{m}{K_1-K_2}}$ (2) $2\pi\sqrt{\frac{m}{K_1+K_2}}$ (3) $\frac{1}{2\pi}\sqrt{\frac{K_1-K_2}{m}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{K_1+K_2}{m}}$

NTA Ans. (2)
Reso Ans. (2)

43. A particle is moving with constant speed in a circular path. When the particle turns by an angle 90°, the ratio of instantaneous velocity to its average velocity is $\pi : x\sqrt{2}$ .The value of x will be–

(1) 1 (2) 7 (3) 5 (4) 2

NTA Ans. (4)
Reso Ans. (4)
Sol.



$$v_{av} = \frac{\text{displacement}}{\text{time}} = \frac{R\sqrt{2}\times 4}{T} \; ; \; v_{av} = \frac{R\sqrt{2}\times 4}{\frac{2\pi R}{V}} \; ; \; \frac{V}{V_{av}} = \frac{2\pi R}{R\sqrt{2}\times 4} = \frac{\pi}{2\sqrt{2}} \; ; \; x = 2$$

44. The Kinetic energy of an electron, α–particle and a proton are given as 4 K, 2 K and K respectively. The de–Broglie wavelength associated with electron (λe), α–particle ($\lambda\alpha$) and the proton (λp) are as follows:

(1) $\lambda\alpha = \lambda p < \lambda e$ (2) $\lambda\alpha > \lambda p > \lambda e$ (3) $\lambda\alpha = \lambda p > \lambda e$ (4) $\lambda\alpha < \lambda p < \lambda e$

NTA Ans. (4)

Reso Ans. (4)

Sol. $\lambda_e = \dfrac{h}{\sqrt{2m_e 4K}}$; $\lambda_p = \dfrac{h}{\sqrt{2m_p K}} < \lambda_e$; $\lambda_\alpha = \dfrac{h}{\sqrt{2(4m_p)2K}} = \dfrac{\lambda_p}{2\sqrt{2}}$

45. A planet has double the mass of the earth. Its average density is equal to that of the earth. An object weighing W on earth will weigh on that planet:

(1) W (2) 2 W (3) $2^{2/3}$ W (4) $2^{1/3}$ W

NTA Ans. (4)

Reso Ans. (4)

Sol. Weight $W_e = mg = \dfrac{mGM}{R^2}$

$$\frac{M}{\frac{4\pi}{3}R_e^3} = \frac{2M}{\frac{4\pi}{3}R_p^3}$$

$$R_p = R_e\, 2^{\frac{1}{3}}$$

Ratio of weight $\Rightarrow \dfrac{We}{Wp} = \dfrac{Me}{Mp} \times \left(\dfrac{R_p}{R_e}\right)^2$

$$\frac{W}{W_p} = \frac{M}{2M} \times (2^{1/3})^2 \Rightarrow \frac{W}{W_p} = 2^{\frac{2}{3}-1} \Rightarrow W_p = W \times 2^{\frac{1}{3}}$$

46. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Earth has atmosphere whereas moon doesn't have any atmosphere.

Reason R: The escape velocity on moon is very small as compared to that on earth.

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

(1) Both A and R are correct and R is the correct explanation of A

(2) A is true but R is false

(3) Both A and R are correct but R is NOT the correct explanation of A

(4) A is false but R is true

NTA Ans. (1)

Reso Ans. (1)

47. A long straight wire of circular cross-section (radius a) is carrying steady current I. The current I is uniformly distributed across this cross-section. The magnetic field is

(1) directly proportional to r in the region r < a and inversely proportional to r in the region r > a

(2) inversely proportional to r in the region r < a and uniform throughout in the region r > a

(3) uniform in the region r < a and inversely proportional to distance r from the axis, in the region r > a

(4) zero in the region r < a <a and inversely proportional to r in the region r > r > a

NTA Ans. (1)

Reso Ans. (1)

Sol. For r < a

$$B = \frac{\mu_0 I r}{2\pi a^2}$$

$\therefore B \propto r$ for r > a

$$B = \frac{\mu_0 I}{2\pi r} \quad \therefore B \propto \frac{1}{r}$$

48. A monochromatic light wave with wavelength λ_1 and frequency v_1 in air enters another medium. If the angle of incidence and angle of refraction at the interface are 45° and 30° respectively, then the wavelength λ_2 and frequency v_2 of the refracted wave are:

(1) $\lambda_2 = \sqrt{2}\lambda_1, v_1 = v_1$ (2) $\lambda_2 = \frac{1}{\sqrt{2}}\lambda_1, v_2 = v_1$

(3) $\lambda_2 = \lambda_1, v_2 = v_1$ (4) $\lambda_2 = \lambda_1, v_2 = \sqrt{2}v_1$

NTA Ans. (2)

Reso Ans. (2)

Sol. $n_1 \sin 45° = n_2 \sin 30°$

$$\frac{C}{V_1} \times \frac{1}{\sqrt{2}} = \frac{C}{V_2} \times \frac{1}{2} \Rightarrow V_1 = \sqrt{2}V_2, \ \lambda_1 = \sqrt{2}\lambda_2$$

49. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: When a body is projected at an angle 45°, it's range is maximum.

Reason R : For maximum range, the value of sin 20 should be equal to one.

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

(1) A is true but R is false

(2) Both A and R are correct but R is NOT the correct explanation of A

(3) Both A and R are correct and R is the correct explanation of A

(4) A is false but R is true

NTA Ans. (3)

Reso Ans. (3)

Sol. (A) $\theta = 45°$

$\Rightarrow R_{max}$

(R) $\sin 2\theta = 1$

$\sin 2\theta = \sin 2(45) = 1$

50. The induced emf can be produced in a coil by

A. moving the coil with uniform speed inside uniform magnetic field

B. moving the coil with non-uniform speed inside uniform magnetic field

C. rotating the coil inside the uniform magnetic field

D. changing the area of the coil inside the uniform magnetic field

Choose the correct answer from the options given below:

(1) B and C only (2) A and C only (3) C and D only (4) B and D only

NTA Ans. (3)

Reso Ans. (3)

51. A steel rod has a radius of 20 mm and a length of 2.0 m. A force of 62.8 kN stretches it along its length. Young's modulus of steel is 2.0 $\times 10^{11}$ N/m^2. The longitudinal strain produced in the wire is _____$\times 10^{-5}$

NTA Ans. 25
Reso Ans. 25
Sol. $F = kx$

$$\frac{yA}{\ell} \times x$$

$$\text{strain} = \frac{x}{\ell} = \frac{F}{yA} = \frac{F}{y \times \pi r^2} = \frac{62.8 \times 10^3}{2 \times 10^{11} \times \pi \times (20 \times 10^{-3})^2} = 25 \times 10^{-5}$$

52. An ideal transformer with purely resistive load operates at 12 kV on the primary side. It supplies electrical energy to a number of nearby houses at 120 V. The average rate of energy consumption in the houses served by the transformer is 60 kW. The value of resistive load (Rs) required in the secondary circuit will be _____ MΩ.

NTA Ans. 240
Reso Ans. 240
Sol. $V_1 = 12$ KV
$V_2 = 120$V
$P_2 = 60$W
$R_2 = ?$

$$P = \frac{V^2}{R}$$

$$R_2 = \frac{V_2^2}{P_2} = \frac{120^2}{60} = 240$$

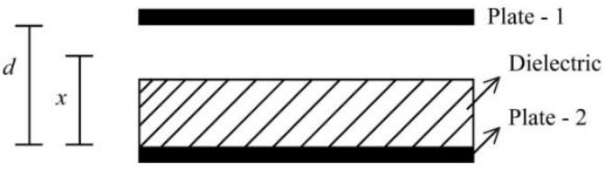
53. The length of a metallic wire is increased by 20% and its area of cross section is reduced by 4%. The percentage change in resistance of the metallic wire is _____.

NTA Ans. 25
Reso Ans. 25
Sol. Suppose initial length of wire = l
cross area sectional = A
And resistivity of material = ρ
$\therefore$ Initial resistance $R = \rho \times \ell/A$

Now Resistance of change $R' = \frac{\rho \cdot [1+0.20]\ell}{A[1-0.04]}$

$R' = 1.25 \frac{\rho\ell}{A} = 1.25R$ $\quad\therefore\quad$ % change $\frac{\Delta R}{R} \times 100 = 25\,\%$

54. A parallel plate capacitor with plate are A and plate separation d is filled with a dielectric material of dielectric constant K = 4. The thickness of the dielectric material is x, where x < d.



Let C_1 and C_2 be the capacitance of the system for $X = \frac{1}{3}d$ and $X = \frac{2d}{3}$, respectively. If $C_1 = 2\mu$F the value of C_2 is _____ μF.

NTA Ans. 3

Reso Ans. 3

Sol. $C_1 = \dfrac{\varepsilon_0 A}{\frac{d}{3k}+\frac{2d}{3}} = \dfrac{\varepsilon_0 A}{\frac{d}{12}+\frac{2d}{3}} = \dfrac{\varepsilon_0 A}{\frac{d}{12}(1+8)} = \dfrac{12\varepsilon_0 A}{9d} = \dfrac{4\varepsilon_0 A}{3d}$

$C_2 = \dfrac{\varepsilon_0 A}{\frac{2d}{3k}+\frac{d}{3}} = \dfrac{\varepsilon_0 A}{\frac{2d}{12}+\frac{d}{3}} = \dfrac{\varepsilon_0 A}{\frac{d}{6}(1+2)} = \dfrac{6\varepsilon_0 A}{3d} = \dfrac{2\varepsilon_0 A}{d}$

$\dfrac{C_1}{C_2} = \dfrac{4/3}{2/1}$; $\dfrac{C_1}{C_2} = \dfrac{4}{2\times 3} = \dfrac{2}{3}$; $C_2 = \dfrac{3}{2}C_1$

$C_2 = 3\mu F$

55. The radius of fifth orbit of the Li^{++} is _____ $\times 10^{-12}$m.

Take: radius of hydrogen atom = 0.51 Å.

NTA Ans. 425

Reso Ans. 425

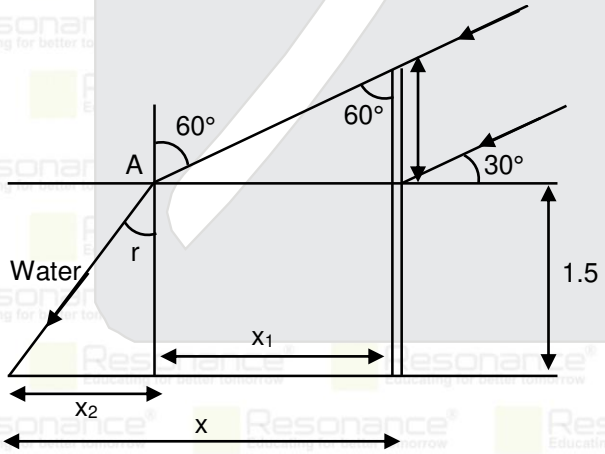
Sol. $r = \dfrac{n^2}{Z}a_0 = \dfrac{5^2}{3}\times 5.3\times 10^{-11}\text{m} \approx 4.4\text{Å}$

56. A pole is vertically submerged in swimming pool, such that it gives a length of shadow 2.15 m within water when sunlight is incident at an angle of 30° with the surface of water. If swimming pool is filled to a height of 1.5 m, then the height of the pole above the water surface in centimetres is ($n_w = 4/3$) .

NTA Ans. 50

Reso Ans. 50

Sol.



$x = 2.15$

$x_1 + x_2 = 2.15$ .....(1)

$\tan 60° = \dfrac{x_1}{h} = \sqrt{3}$

$x_1 = h\sqrt{3}$

Snell's law

$1 \times \sin 60° = 4/3 \times \sin r$

$$\frac{\sqrt{3}}{2}\times\frac{3}{4}=\sin r \qquad \ldots\ldots(2)$$

$$\tan r=\frac{x_2}{1.5}$$

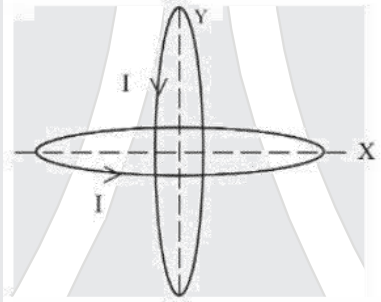
$$x_2=\frac{3\sqrt{3}\times1.5}{\sqrt{37}} \qquad \ldots..(3)$$

from equation (1) & (3)

$$h\sqrt{3}+\frac{3\sqrt{3}\times1.5}{\sqrt{37}}=2.15$$

h = 0.5 m = 50 cm

57. Two identical circular wires of radius 20 cm and carrying current $\sqrt{2}$ A are placed in perpendicular planes as shown in figure. The net magnetic field at the centre of the circular wires is _____ × 10^{-8} T.



(Take π = 3.14)

NTA Ans. 628

Reso Ans. 628

Sol. $B=\frac{\mu_0 Ni}{2R}$

$$=\left(\frac{4\pi\times10^{-7}\times\sqrt{2}}{2\times0.2}\right)\times\sqrt{2}$$

$= 2\pi \times 10^{-6} = 6.28 \times 10^{-6} = 628 \times 10^{-8}$ T

58. Two identical solid spheres each of mass 2 kg and radii 10 cm are fixed at the ends of a light rod. The separation between the centres of the spheres is 40 cm. The moment of inertia of the system about an axis perpendicular to the rod passing through its middle point _____ is × 10^{-3} kg-m^2

NTA Ans. 176

Reso Ans. 176

Sol. $I=2\left[\frac{2}{5}mR^2+md^2\right]$

d = 20 cm = 2R

$$I=2\left[\frac{2}{5}mR^2+4mR^2\right]=\frac{44}{5}MR^2=176\times10^{-3}\ \text{kg.m}^2$$

59. A particle of mass 10 g moves in a straight line with retardation 2x, where x is the displacement in SI units. Its loss of kinetic energy for above displacement is $\left(\frac{10}{x}\right)^{-n}$ J. The value of n will be _____.

NTA Ans. 2
Reso Ans. 2
Sol. $W = \Delta KE$

$$W\int Fdx = -\int madx = -\int \frac{10}{1000}\times 2xdx$$

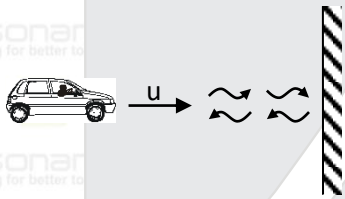
$$\Delta KE = -\frac{1}{100}\times 2\times\frac{x^2}{2}$$

$$-\Delta KE = \left(\frac{x}{10}\right)^2 = \left(\frac{10}{x}\right)^{-2} = \left(\frac{10}{x}\right)^{-n}$$

$n = 2$

60. A person driving car at a constant speed of 15 m/s is approaching a vertical wall. The person notices a change of 40Hz in the frequency of his car's horn upon reflection from the wall. The frequency of horn is _____Hz. (Given: Speed of sound : 330 m/s)

NTA Ans. 420
Reso Ans. 420
Sol.



$$f_{app.} = f_0 \times \left(\frac{v+u}{v-u}\right)$$

$$\Delta f = f_{app} - f_0$$

$$\Delta f = f_0\ \frac{2u}{v-u}$$

$$40 = f_0\left(\frac{2\times 15}{330-15}\right)$$

$f_0 = 420$