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JEE (Main)

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

2023

COMPUTER BASED TEST (CBT)
Questions & Solutions

Date: 10 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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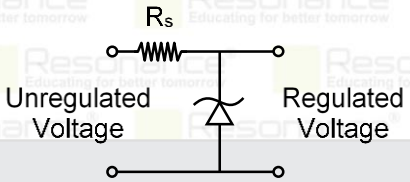
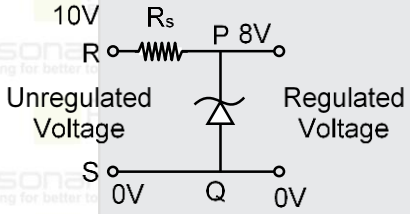
PART : PHYSICS

31. A zener diode of power of rating 1.6 W is to be used as voltage regulator. If the zener diode has a breakdown of 8 V and it has to regulate voltage fluctuating between 3 V and 10 V. The value of resistance R_s for safe operation of diode will be



(1) 13 Ω (2) 10 Ω (3) 13.3 Ω (4) 12 Ω

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



V_Q = Q volt

$V_P - V_q$ = Q volt

Current through zener diode

$$i = \frac{P}{V} = \frac{1.6W}{8} = 0.2A$$

$V_R - V_P$ (10–8) volt

$$R = \frac{V_C - V_A}{I} = \frac{2V}{0.2A} \Rightarrow$$ 10.00 Option (2)

32. Given below are two statements :
Statement I : Pressure in a reservoir of water is same at all points at the same level of water.
Statement II : The pressure applied to enclosed water is transmitted in all directions equally.
In the light of the above statements, choose the correct answer from the options given below :
(1) Both Statement I and Statement II are false
(2) Both Statement I and Statement II are true
(3) Statement I is true but Statement II is false
(4) Statement I is false but Statement II is true

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

33. The angular momentum for the electron in Bohr's orbit is L. If the electron is assumed to revolve in second orbit of hydrogen atom, then the change in angular momentum will be

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

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

Sol. $L = mvr$

$\because \quad r \propto n^2$

$\because \quad v \propto 1/n$

$L \propto n$

also $L = \frac{nh}{2\pi}$

$L_1 = \frac{1.h}{2\pi}$

$L_2 = \frac{2.h}{2\pi}$

$\therefore$ Change $(L_2 - L_1)$

$= 2L - L = L$

34. Match List I with List II :

List I	**List II**
(A) 3 Translation degrees of freedom	(I) Monoatomic gases
(B) 3 Translation, 2 rotational degrees of freedoms	(II) Polyatomic gases
(C) 3 Translation, 2 rotational and 1 vibrational degrees of freedom	(III) Rigid diatomic gases
(D) 3 Translation, 3 rotational and more than one vibrational degrees of freedom	(IV) Nonrigid diatomic gases

Choose the correct answer from the options given below :

(1) (A)-(I), (B)-(IV), (C)-(III), (D)-(II) (2) (A)-(IV), (B)-(III), (C)-(II), (D)-(I)

(3) (A)-(IV), (B)-(II), (C)-(I), (D)-(III) (4) (A)-(I), (B)-(III), (C)-(IV), (D)-(II)

NTA Ans. (4)

Reso Ans. (4)

Sol. Factual

35. A carrier wave of amplitude 15 V is modulated by a sinusoidal base band signal of amplitude 3 V. The ratio of maximum amplitude to minimum amplitude in an amplitude modulated wave is

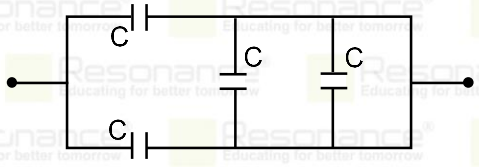
(1) 2 (2) 5 (3) 3/2 (4) 1

NTA Ans. (3)

Reso Ans. (3)

Sol. $\frac{A_{max}}{A_{min}} = \frac{A_C + A_M}{A_C - A_M} = \frac{15+3}{15-3} = \frac{3}{2}$

36. The equivalent capacitance of the combination shown is

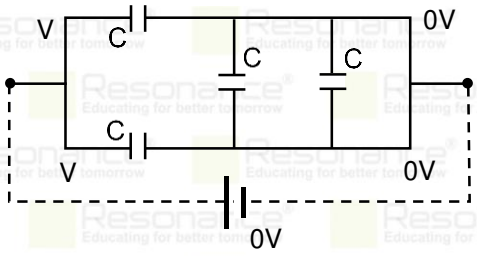


(1) $\frac{C}{2}$ (2) $\frac{5}{3}C$ (3) 4C (4) 2C

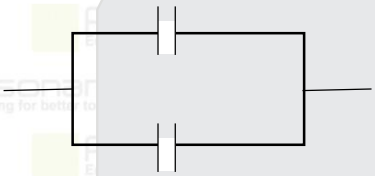
NTA Ans. (4)

Reso Ans. (4)

Sol.



The circuit can be reduced



$C_{eq} = C + C = 2C$

37. Given below are two statements :

Statement I : If the number of turns in the coil of a moving coil galvanometer is doubled then the current sensitivity becomes double.

Statement II : Increasing current sensitivity of a moving coil galvanometer by only increasing the number of turns in the coil will also increase its voltage sensitivity in the same ratio

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) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are false
(4) Both Statement I and Statement Ii are true

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

Sol. Current sensitivity = $\frac{BNA}{K}$

Voltage sensitivity = $\frac{BNA}{KR}\theta$

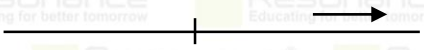
(1) if N is doubled then current sensitivity is doubled
(2) N doubled, R is also doubled, No change in voltage sensitivity

38. A particle executes S.H.M. of amplitude A along x-axis. At t = 0, the position of the particle is $x = \frac{A}{2}$ and it moves along positive x-axis. The displacement of particle in time t is $x = A\sin(\omega t + \delta)$, then the value of δ will be

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

NTA Ans. (1)
Reso Ans. (1)

Sol.



$x = A\sin(\omega t + \delta)$

$$\frac{A}{2} = A\sin(\omega rt + \delta)$$

$$\sin\frac{\pi}{6} = \delta$$

$$\delta = \frac{\pi}{6}$$

39. The energy of an electromagnetic wave contained in a small volume oscillates with

(1) the frequency of the wave (2) half the frequency of the wave

(3) double the frequency of the wave (4) zero frequency

NTA Ans. (3)

Reso Ans. (3)

Sol. $K = E_0\sin(\omega t - kx)$

$E = E_0\sin(\omega t - kx)$

Energy density $\frac{du}{dv} = \varepsilon_0 E^2(\sin^2(\omega t - kx)) = \frac{\varepsilon_0 E^2}{2}[1 - \cos(2\omega t - 2kx)]$

40. Consider two containers A and B containing monoatomic gases at the same pressure (P), Volume (V) and Temperature (T). The gas in A is compressed isothermally to 1/8 of its original volume while the gas in B is compressed adiabatically to 1/8 of its original volume. The ratio of final pressure of gas in B to that of gas in A is

(1) 8 (2) $8^{\frac{3}{2}}$ (3) 4 (4) $\frac{1}{8}$

NTA Ans. (3)

Reso Ans. (3)

Sol. Isothermal process

$$PV = P_A\left(\frac{V}{8}\right)$$

$P_A = 8P$ ...(i)

Addiabatic process

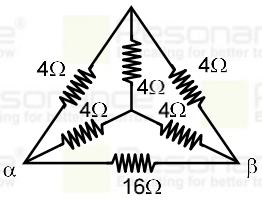
$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$$\frac{P_B}{P} = \left(\frac{V_1}{V_2}\right)^{\gamma}; \quad \frac{P_B}{P} = \left(\frac{V}{V/8}\right)^{5/3}$$

$P_B = 32P$

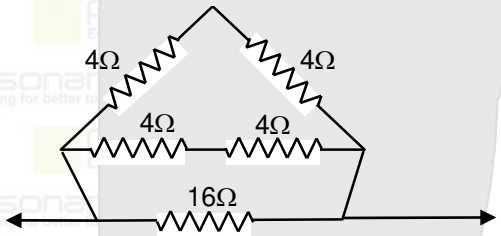
$$\frac{P_B}{P_A} = \frac{32P}{8P} = 4$$

41. The equivalent resistance of the circuit shown below between points a and b is :



(1) 3.2 Ω (2) 24 Ω (3) 20 Ω (4) 16 Ω

NTA Ans. (1)
Reso Ans. (1)
Sol.

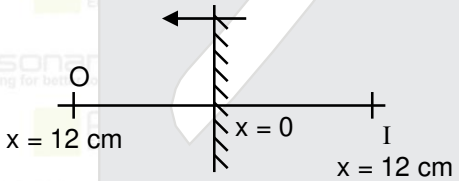


$$R_{eq} = \frac{16 \times 4}{16 + 4} = \frac{16}{5} = 3.2\ \Omega$$

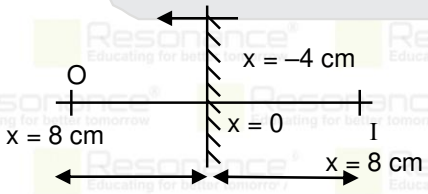
42. An object is placed at a distance of 12 cm in front of a plane mirror. The virtual and erect image is formed by the mirror. Now the mirror is moved by 4 cm towards the stationary object. The distance by which the position of image would be shifted, will be

(1) 8 cm towards mirror (2) 2 cm towards mirror
(3) 8 cm away from mirror (4) 4 cm towards mirror

NTA Ans. (1)
Reso Ans. (1)
Sol. Initial



Final



$$\rightarrow \frac{\text{at resonance}}{X_L = X_C}$$

Z_{min} = R (Pure resistive)

43. Given below are two statements :

Statement I : Maximum power is dissipated in a circuit containing an inductor, a capacitor and a resistor connected in series with an AC source, when resonance occurs

Statement II : Maximum power is dissipated in a circuit containing pure resistor due to zero phase difference between current and voltage.

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

(1) Both Statement I and Statement II are true (2) Both Statement I and Statement Ii are false

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

NTA Ans. (1)

Reso Ans. (1)

Sol. Impedance

$Z = \sqrt{R^2 + (X_L - X_L)^2}$ at Resonance $X_L = X_C$

$Z_{min} = R$ (Pure resistive)

44. Two satellites of masses m and 3m revolve around the earth in circular orbits of radii r & 3r respectively. The ratio of orbital speeds of the satellites respectively is

(1) 1 : 1 (2) $\sqrt{3}:1$ (3) 3 : 1 (4) 9 : 1

NTA Ans. (2)

Reso Ans. (2)

Sol. $V = \sqrt{\frac{GM}{r}}$

$V \propto \frac{1}{\sqrt{r}}$

$\frac{V_1}{V_2} = \sqrt{\frac{r_2}{r_1}} = \sqrt{\frac{3}{1}} = \sqrt{3}:1$

45. The de Broglie wavelength of a molecule in a gas at room temperature (300 K) is λ_1. If the temperature of the gas is increased to 600 K, then the de Broglie wavelength of the same gas molecule becomes :

(1) $\frac{1}{2}\lambda_1$ (2) $\frac{1}{\sqrt{2}}\lambda_1$ (3) $\sqrt{2}\lambda_1$ (4) $2\lambda_1$

NTA Ans. (2)

Reso Ans. (2)

Sol. $\lambda = \frac{h}{P} = \frac{h}{m V_{rms}}$

From K.T.G. $V_{rms} \propto \sqrt{T}$

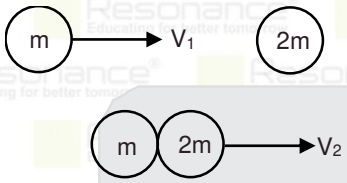
$\lambda \propto \frac{1}{\sqrt{T}}$

$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{300}{600}} = \frac{1}{\sqrt{2}}$

46. A particle of mass m moving with velocity v collides with a stationary particle of mass 2m. After collision, then stick together and continue to move together with velocity

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

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



$P_i = P_f$

$mv_1 + 2m \times 0 = (3\ m)V_2$

$V_2 = V/3$

47. A physical quantity P is given as $P = \frac{a^2b^3}{c\sqrt{d}}$. The percentage error in the measurement of a, b, c and d are 1%, 2%, 3% and 4% respectively. The percentage error in the measurement of quantity P will be

(1) 12% (2) 14% (3) 16% (4) 13%

NTA Ans. (4)
Reso Ans. (4)
Sol. $\left|\frac{\Delta P}{P}\right| \times 100 = \left(\frac{2\Delta a}{a} + \frac{2\Delta b}{b} + \frac{2\Delta c}{c} + \frac{1}{2}\frac{\Delta d}{d}\right) \times 100$

$(2 \times 1 + 3 \times 2 + 3 + \frac{1}{2} \times 4) = 13\%$

48. The range of the projectile projected at an angle of 15º with horizontal is 50 m. If the projectile is projected with same velocity at an angle of 45º with horizontal, then its range will be

(1) $100\sqrt{2}$ m (2) 50 m (3) 100 m (4) $50\sqrt{2}$ m

NTA Ans. (3)
Reso Ans. (3)
Sol. $R \propto \sin 2\theta$

$\frac{R_1}{R_2} = \frac{\sin(2\times 15°)}{\sin(2\times 45°)} = \frac{\sin 30°}{\sin 90°} = \frac{1}{2}$

$\frac{50}{R_2} = \frac{1}{2}$

$R_2 = 100$ m

49. Assuming the earth to be a sphere of uniform mass density, the weight of a body at a depth $d = \frac{R}{2}$ from the surface of earth, if its weight on the surface of earth is 200 N, will be :
(Given R = radius of earth)

(1) 400 N (2) 500 N (3) 300 N (4) 100 N

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

Sol. $M = \frac{\omega}{g} = \frac{200}{10} = 20kg$

g due to gravity at a depth

$g_d = g\left(1-\frac{d}{R}\right)$

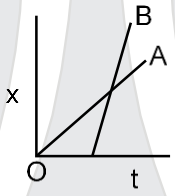
$g_d = g\left(1-\frac{R/2}{R}\right) = \frac{g}{2} = 5\ m/s^2$

$w = mg$

at $d = R/2$

$\Rightarrow 20 \times 5 = 100\ N$

50. The position-time graphs for two students A and B returning from the school to their home are shown in figure.



(A) A lives closer to the school
(B) B lives closer to the school
(C) A takes lesser time to reach home
(D) A travels faster than B
(E) B travels faster than A
Choose the correct answer from the options given below :
(1) (B) and (E) only
(2) (A) and (E) only
(3) (A), (C) and (E) only
(4) (A), (C) and (D) only

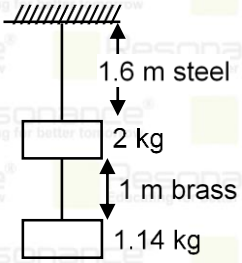
NTA Ans. (2)
Reso Ans. (2)

Sol. Slope of B > slope of A

$\therefore V_B > V_A$

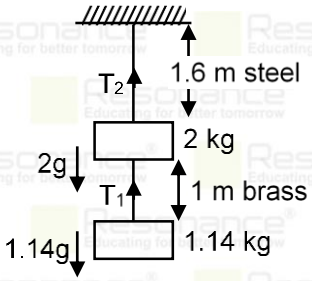
and $T_B \propto T_A$

51. Two wires each of radius 0.2 cm and negligible mass, one made of steel and the other made of brass are loaded as shown in the figure. The elongation of the steel wire is _____ $\times 10^{-6}$m. [Young's modulus for steel = $2 \times 10^{11}\ Nm^{-2}$ and $g = 10\ ms^{-2}$]



NTA Ans. 20.00
Reso Ans. 20.00

Sol.



Steel wire (T_2) = $2g + T_1$

$T_2 = 20 + 11.4 = 31.4$ N

$$\Delta L = \frac{T_2 L}{Ay} = 31.4 \times 1.6 = \frac{31.4 \times 1.6}{\pi(0.2\times10^{-2})^2 2\times10^{11}} = 20\times10^{-6}\text{m}$$

52. A transverse harmonic wave on a string is given by

$$y(x, t) = 5\sin(6t + 0.003x)$$

where x and y are in cm and t in sec. The wave velocity is _____ ms^{-1}.

NTA Ans. 20.00

Reso Ans. 20.00

Sol. $K = 0.003\ cm^{-1}$

$w = 6$ rad/sec

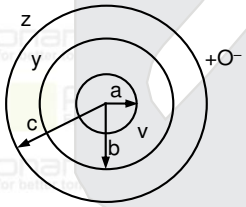
$$v = \frac{w}{K} = 20\ m/s$$

53. Three concentric spherical metallic shells X, Y and Z of radius a, b and c respectively [a < b < c] have surface charge densities σ, $-\sigma$ and σ, respectively. The shells X and Z are at same potential. If the radii of X & Y are 2 cm and 3 cm, respectively. The radius of shell Z is _____cm.

NTA Ans. 05.00

Reso Ans. 05.00

Sol.



$V_x = V_z$

$$\frac{q_x}{4\pi\varepsilon_0 a} + \frac{q_y}{4\pi\varepsilon_0 b} + \frac{q_c}{4\pi\varepsilon_0 c} = \frac{q_x}{4\pi\varepsilon_0 c} + \frac{q_y}{4\pi\varepsilon_0 c} + \frac{q_z}{4\pi\varepsilon_0 c}$$

$$\frac{\sigma 4\pi a^2}{a} - \frac{\sigma 4\pi b^2}{b} + \frac{\sigma 4\pi c^2}{c} = \frac{4\pi\sigma(a^2 - b^2 + c^2)}{c}$$

$c(a - b + c) = a^2 + b^2 + c^2$

$c(a - b) = a^2 - b^2$

$c = a + b$

$c = 5$ cm

54. The decay constant for a radioactive nuclide is 1.5×10^{-5} s^{-1}. Atomic weight of the substance is 60 g $mole^{-1}$, ($N_A = 6 \times 10^{23}$). The activity of 1.0 μg of the substance is _____ $\times 10^{10}$ Bq.

NTA Ans. 15.00
Reso Ans. 15.00

Sol. No of mole = $\frac{10^{-6} \times 1}{60} = \frac{10^{-7}}{6}$

No of atoms = No of mole $\times N_A = \frac{10^{-7}}{6} \times 6 \times 10^{23} = 10^{16}$

$A = N_0\lambda e^{-\lambda t}$

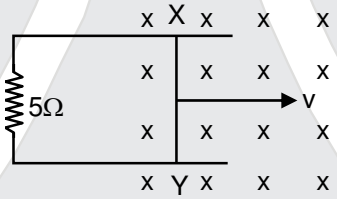
For t = 0, $A = A_0 = N_0\lambda$

$= 1.5 \times 10^{-5} \times 10^{16} = 15 \times 10^{10}$ Bq

55. 10 resistors each of the resistance 10Ω can be connected in such as to get maximum and minimum equivalent resistance. The ratio of maximum and minimum equivalent resistance will be _____.

NTA Ans. 100
Reso Ans. 100

56. A 1 m long metal rod XY completes the circuit as shown in figure. The plane of the circuit is perpendicular to the magnetic field of flux density 0.15 T. If the resistance of the circuit is 5Ω, the force needed to move the rod in direction, as indicated, with a constant speed of 4m/s will be _____ 10^{-3} N.



NTA Ans. 18
Reso Ans. 18

Sol. $F = i\ell B$

$$= \left(\frac{E}{R}\right)\ell B = \left(\frac{B\ell v}{R}\right) \times B = \left(\frac{B\ell v}{R}\right) \times \ell B = \frac{vB^2\ell^2}{R} = \frac{4}{5}\left(\frac{15}{100}\right)^2 \times \ell^2 = \frac{4}{5} \times \frac{225}{10^4} = 18 \times 10^{-3} \text{ N}$$

57. The current required to be passed through a solenoid of 15 cm length and 60 turns in order to demagnetise a bar magnet of magnetic intensity 2.4×10^3 Am^{-1} is _____A.

NTA Ans. 6
Reso Ans. 6

Sol. I = h

Given $I = 2.4 \times 10^3$ A/m

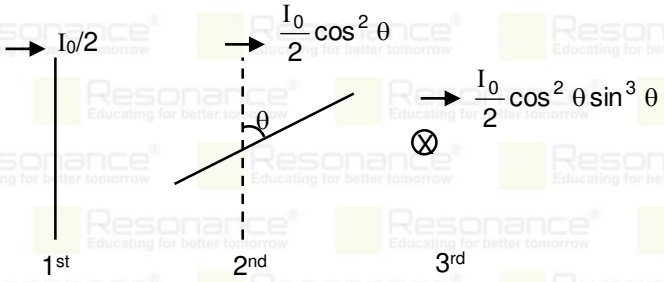
$2.4 \times 10^3 = H = ni$

$$n = \frac{N}{\ell} \Rightarrow 2.4 \times 10^3 = \frac{60}{15 \times 10^{-2}} i \Rightarrow i = \frac{2.4 \times 15 \times 10}{60} = \frac{36}{6} = 6A$$

58. Unpolarised light of intensity 32 Wm^{-2} passes through the combination of three polaroids such that the pass axis of the last polaroid is perpendicular to that of the pass axis of first polaroid. If intensity of emerging light is 3 Wm^{-2}, then the angle between pass axes of first two polariods is _____.

NTA Ans. 30
Reso Ans. 30

Sol. $I_0 = 32 W/m^2$



$I_{net} = 3$

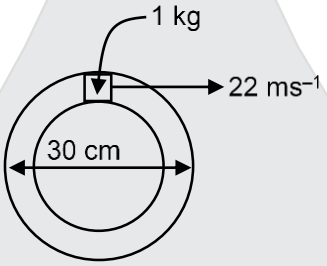
$= \frac{32}{2}\cos^2\theta\sin^2\theta$

$\frac{3}{4} = 4\sin^2\theta\cos^2\theta \quad = (\sin 2\theta)^2$

$\frac{\sqrt{3}}{2} = \sin(2\theta)$

$\theta = 30°$

59. A closed circular tube of average radius 15 cm, whose inner walls are rough, is kept in vertical plane, A block of mass 1 kg fit inside the tube. The speed of block is 22 m/s, when it is introduced at the top of tube. After completing five oscillation, the block stops at the bottom region of tube. The work done by the tube on the block is _____J. (Given g = 10 m/s²).



NTA Ans. 245
Reso Ans. –245

Sol. $W_f + W_g = \frac{1}{2}M[v^2 - u^2]$

$W_f + 10 \times 10.3 = -1/2 \times 484 \Rightarrow \quad W_f = -245\ J$

60. If the earth suddenly shrinks to $\frac{1}{64}$th of its original volume with its mass remaining the same, the period of rotation of becomes $\frac{24}{x}$h. The value of x is _____.

NTA Ans. 16
Reso Ans. 16

Sol. By conservation of angular momentum $\frac{2}{5}MR^2\omega_f = \frac{2}{5}m\left(\frac{R}{4}\right)^2\omega_2$

$\frac{\omega_1}{\omega_2} = \frac{1}{16} \Rightarrow \quad \frac{T_1}{T_2} = \frac{16}{1} = \frac{t_1}{x} \quad ; \quad t_1 \Rightarrow 24 = \frac{16}{1} = \frac{24}{t_2}$

$x = 16$