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JEE (Main)

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

2023

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 06 April, 2023 (SHIFT-2) | TIME : (3.00 p.m. to 6.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

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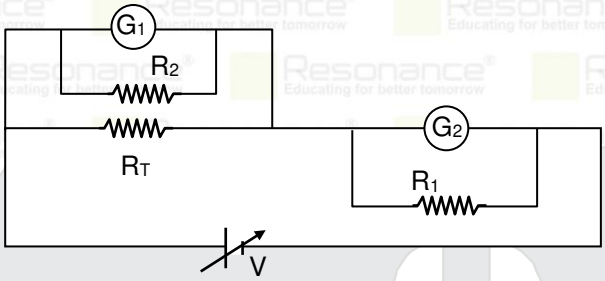
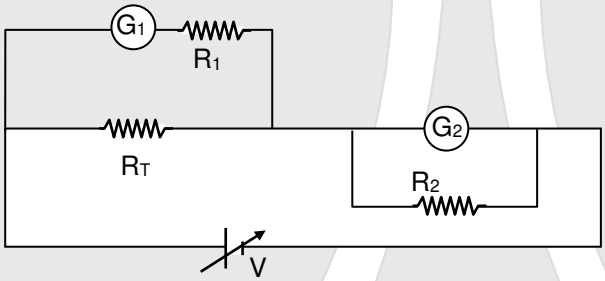
PART : PHYSICS

31. A student is provided with a variable voltage source V, a test resistor R_T = 100 Ω, two identical galvanometers G_1 and G_2 and two additional; resistors, R_1 = 10MΩ and R_2 = 0.001Ω. For conducting an experiment to verify ohm's law, the most suitable circuit is :

(1)



(2)



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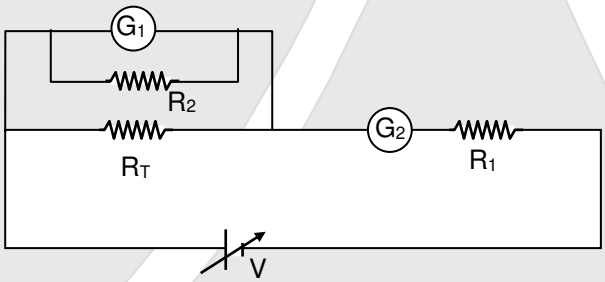

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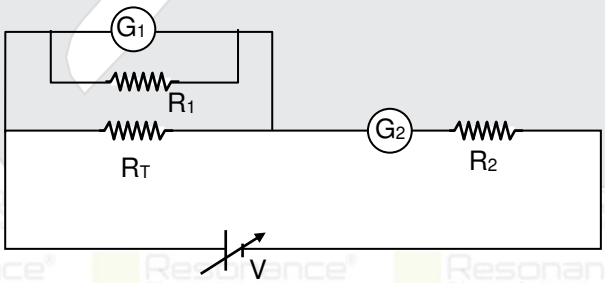


NTA Ans. (2)

Reso Ans. (2)

Sol. Voltmeter required high resistance in series to galvanometer and connected parallel with test resistance

Ammeter required small resistance in parallel to galvanometer and connected series with test resistance

32. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : Diffusion current in a p-n junction is greater than the drift current in magnitude if the junction is forward biased.
Reason R : Diffusion current in a p-n junction is form the n-side to the p-side if the junction is forward biased.
In the light of the above statements, choose the most appropriate answer from the options given below.
(1) Both A and R are correct but R is NOT the correct explanation of A
(2) A is correct but R is not correct
(3) Both A and R are correct and R is the correct explanation of A
(4) A is not correct but R is correct

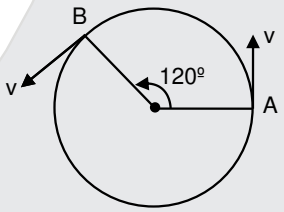
NTA Ans. (2)
Reso Ans. (2)
Sol. Diffusion current through diode is from P side to N side

33. The energy density associated with electric field $\vec{E}$ and magnetic field $\vec{B}$ of an electromagnetic wave in free space is given by (ϵ_0 – permittivity of free space, μ_0 – permeability of free space)

(1) $U_E = \frac{\epsilon_0 E^2}{2}$, $U_B = \frac{\mu_0 B^2}{2}$
(2) $U_E = \frac{\epsilon_0 E^2}{2}$, $U_B = \frac{B^2}{2\mu_0}$
(3) $U_E = \frac{E^2}{2\epsilon_0}$, $U_B = \frac{B^2}{2\mu_0}$
(4) $U_R = \frac{E^2}{2\epsilon_0}$, $U_B = \frac{\mu_0 B^2}{2}$

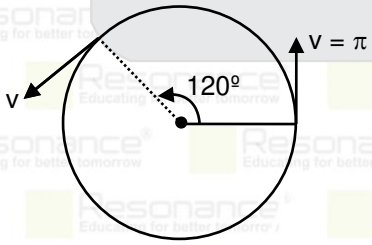
NTA Ans. (2)
Reso Ans. (2)

34. As shown in the figure, a particle is moving with constant speed π m/s. Considering its motion from A to B, the magnitude of the average velocity is :



(1) $\sqrt{3}$ m/s
(2) 1.5 $\sqrt{3}$ m/s
(3) π m/s
(4) $2\sqrt{3}$ m/s

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



$$V_{av} = \frac{s}{t} = \frac{\text{dsiplacmen t}}{\text{time}} = \frac{2R\sin\theta/2}{\left(\frac{R\theta}{v}\right)} = \frac{2R\sin\frac{2\pi/3}{2}}{\left[\frac{R\left(\frac{2\pi}{3}\right)}{v}\right]} = 2R\frac{\sqrt{3}}{2}\frac{v}{R\left(\frac{2\pi}{3}\right)} = \frac{3\sqrt{3}v}{2\pi} = 1.5\sqrt{3}$$

35. A capacitor of capacitance 150.0 μF is connected to an alternating source of emf given by E = 36 sin (120 πt) V. The maximum value of current in the circuit

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

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

Sol. $x_C = \frac{1}{\omega C} = \frac{1}{150\times10^{-6}\times120\pi} = \frac{1}{18000\times10^{-6}\pi} = \frac{10^3}{18}$

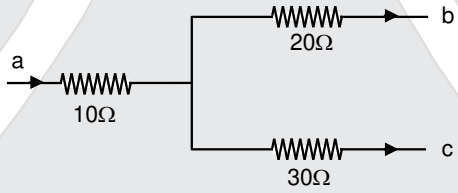
$I_{max} = \frac{V_{max}}{x_C} = \frac{36\times18\pi}{10^3} = 2.03 \approx 2$

36. Given below are two statement : one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : The phase difference of two light waves change if they travel through different media having same thickness, but different indices of refraction.
Reason R : The wavelengths of waves are different in different media. In the light of the above statements, choose the most appropriate answer from the options given below
(1) Both A and R are correct but R is NOT the correct explanation of A
(2) A is correct but R is not correct
(3) A is not correct but R is correct
(4) Both A and R are correct and R is the correct explanation of A

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

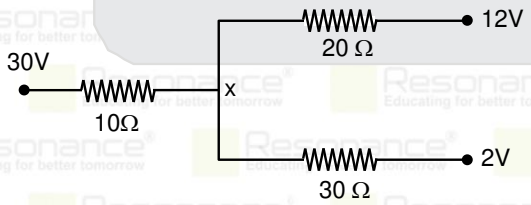
Sol. $\frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$

37. Figure shows a part of an electric circuit. The potentials at points a, b and c are 30 V, 12 V and 2 V respectively. The current through the 20Ω resistor will be



(1) 0.4 A (2) 1.0A (3) 0.6 A (4) 0.2 A

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



Using KCL

$\frac{30-x}{10}+\frac{12-x}{20}+\frac{2-x}{30}=0$

$\Rightarrow 6(30-x)+3(12-x)+2(2-x)=0 \Rightarrow 180-6x+36-3x+4-2x=0 \Rightarrow x=\frac{220}{11} \Rightarrow x = 20$ Volt

so current in 20Ω resistance is

$i = \frac{20-12}{20} = \frac{8}{20} = 0.4$ A

38. For an amplitude modulated wave the minimum amplitude is 3 V, while the modulation index is 60%. The maximum amplitude is 3V, while the modulation index is 60% . The maximum amplitude of the modulated wave is :

(1) 10V (2) 5 V (3) 12 V (4) 15V

NTA Ans. (3)

Reso Ans. (3)

Sol. $\mu = \frac{A_m}{A_c} = 0.6 \Rightarrow A_m = 0.6A_C$

$(A_{eq})_{min} = A_C - A_m = A_C - 0.6A_C = 0.4\ A_c$

$A_m = 1.5$ Volt

$(A_{eq})_{max.} = A_C + A_m = 0.6A_C + A_C = 1.6A_C$

$\frac{A_{max}}{A_{min}} = \frac{1.6A_C}{0.4A_C} = 4$

$A_{max} = 12$

39. The weight of a body on the surface of the earth is 100 N. The gravitational force on it when taken at a height, from the surface of earth equal to one-fourth the radius of the earth is :

(1) 64 N (2) 25 N (3) 50 N (4) 100 N

NTA Ans. (1)

Reso Ans. (1)

Sol. $g' = \frac{g}{\left(1+\frac{h}{R}\right)^2}$

$g' = \frac{g}{\left(1+\frac{R/4}{R}\right)^2} \Rightarrow g' = \frac{16}{25}g \Rightarrow mg' = \frac{16}{25}mg \Rightarrow mg' = \frac{16}{25}\times 100 = 64\ N$

40. The work function of Aluminium and Gold are 4.1 eV and 5.1 eV respectively. The ratio of the stopping potential versus frequency plot for Gold to that of Aluminium is

(1) 2 (2) 1.5 (3) 1.24 (4) 1

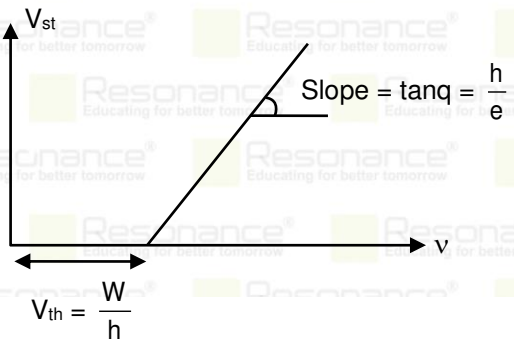
NTA Ans. (4)

Reso Ans. (4)

Sol. $KE_{max} = h\nu - W$

$eV_{st} = h\left(\nu - \frac{W}{h}\right); V_{st} = \frac{h}{e}\left(\nu - \frac{W}{h}\right)$

slope = h/e = same for each material



41. A particle start with an initial velocity of 10.0 ms^{-1} along x-direction and accelerates uniformly at the rate of 2.0 ms^{-2}. The time taken by the particle to reach the velocity of 60.0 ms^{-1} is___.

(1) 3s (2) 30s (3) 25 s (4) 6s

NTA Ans. (3)

Reso Ans. (3)

Sol. $V = 4 + at$

$60 = 10 + (2)(t)$

$t = \frac{50}{2} = 25$ m/s

42. The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is

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

NTA Ans. (2)

Reso Ans. (2)

Sol. $T_1 = T_2$ and $\gamma_1 = \gamma_2$ (Both diatomic)

$$\frac{V_{H_2}}{V_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}} = \sqrt{\frac{32}{2}} = \frac{4}{1}$$

43. Choose the incorrect statement from the following

(1) The speed of satellite in a given circular orbit remains constant.

(2) When a body falls towards earth, the displacement of earth towards the body is negligible.

(3) The linear speed of a planet revolving around the sun remains constant.

(4) For a planet revolving around the sun in an elliptical orbit, the total energy of the planet remains constant.

NTA Ans. (3)

Reso Ans. (3)

Sol. Theory based

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

Assertion A: When you squeeze one end of a tube to get toothpaste out from the other end, Pascal's principle is observed.

Reason R : A change in the pressure applied to an enclosed incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.

In the light of the above statements, choose the most appropriate answer from the options given below

(1) Both A and R are correct but R is NOT the correct explanation of A
(2) Both A and R are correct and R is the correct explanation of A
(3) A is not correct but R is correct
(4) A is correct but R is not correct

NTA Ans. (2)

Reso Ans. (2)

Sol. Theory based

45. A small particle of mass m moves in such a way that its potential energy $U = \frac{1}{2} m \omega^2 r^2$ where ω is constant and r is the distance of the particle from origin. Assuming Bohr's quantization of momentum and circular orbit, the radius of n_{th} orbit will be proportional to.

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

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

Sol. $mvr = \frac{nh}{2\pi}$

$m\omega r^2 = \frac{nh}{2\pi}$

$r \propto \sqrt{n}$

46. A child of mass 5 kg is going round a merry -go round that makes 1 rotation in 3.14 s. The radius of the merry-go-round in 2m. The centrifugal force on the child will be

(1) 100 N (2) 80 N (3) 40 N (4) 50 N

NTA Ans. (3)
Reso Ans. (3)

Sol. $F_c = m\omega^2 R = m\left(\frac{2\pi}{T}\right)^2 R$

Here $T = 3.14 = \pi$

$= 5\left(\frac{2\pi}{\pi}\right)^2 (2) = 40\,N$

47. A dipole comprises of two charged particles of identical magnitude q and opposite in nature. The mass 'm' of the positive charged particle is half of the mass of the negative charged particle. The two charges are separated by a distance 'ℓ' .If the dipole is placed in a uniform electric field '$\vec{E}$': in such a way that dipole axis makes a very small angle with the electric field '$\vec{E}$. The angular frequency of the oscillations of the dipole when released is given by :

(1) $\sqrt{\frac{8qE}{m\ell}}$ (2) $\sqrt{\frac{4qE}{m\ell}}$ (3) $\sqrt{\frac{4qE}{3m\ell}}$ (4) $\sqrt{\frac{8qE}{3m\ell}}$

NTA Ans. (3)
Reso Ans. Bonus

Sol $I_{cm} = \mu\ell^2$

$= \frac{m(2m)}{m+2m}\ell^2 = \frac{mg\ell^2}{3}$

$-PE\sin\theta = I\alpha$

$\therefore \alpha = \frac{PE\,\theta}{I}$

$\therefore\ \omega = \sqrt{\frac{PE}{I}} = \sqrt{\frac{q\ell E}{\frac{2}{3}m\ell^2}} = \sqrt{\frac{3qE}{2m\ell}} = \sqrt{\frac{1.5qE}{m\ell}}$

Closest option will be (3) $\sqrt{\frac{4qE}{3m\ell}} = \sqrt{\frac{1.33qE}{m\ell}}$

48. A body cools in 7 minutes from 60ºC to 40ºC. The temperature of the surrounding is 10ºC. The temperature of the body after the next 7 minutes

(1) 34ºC (2) 32ºC (3) 28ºC (4) 30ºC

NTA Ans. (3)

Reso Ans. (3)

Sol. $\frac{dQ_{loss}}{dt} = -ms\frac{dT}{dt} = KA(T - T_0)$

$$ms\frac{(60-40)}{7min} = KA\left[\left(\frac{60+40}{2}\right) - 10\right] \quad .....(i)$$

$$ms\frac{40-T_f}{7min} = KA\left[\frac{40+T_f}{2} - 10\right] \quad ...(ii)$$

Dividing: $T_f = 28°C$

49. A 2 meter long scale with least count of 0.2 cm is used to measure the locations of objects on an optical bench. While measuring the focal length of a convex lens, the object pin and the convex lens are placed at 80 cm make and 1m mark, respectively. The image of the object pin on the other side of lens coincides with image pin that is kept at 180 cm mark. The % error in the estimation of focal length is

(1) 0.85 (2) 1.02 (3) 0.51 (4) 1.70

NTA Ans. (4)

Reso Ans. (4)

Sol. $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$$\frac{1}{f} = \frac{1}{80} - \frac{1}{-20} = \frac{1}{16}$$

$f = 16$

error in f

$$\frac{df}{f^2} = \pm\left[\frac{du}{u^2} + \frac{dv}{v^2}\right]$$

$$\frac{df}{f} = \pm\left[\frac{0.4}{2.0^2} + \frac{0.4}{80^2}\right] \times 16$$

$$\frac{df}{f} \times 100 = \pm 16 \times 0.4\left[\frac{6400+400}{6400\times 400}\right] \times 100\%$$

$$= \pm 16 \times 0.4 \times \frac{68}{64} \times \frac{1}{4}\%$$

$$\pm\frac{6.8}{4} \times \frac{1}{4}\% = \pm 1.7\%$$

50. The temperature of an ideal gas is increased from 200 K to 800 K. If r.m.s. speed of gas at 200 K is v_0. Then, r.m.s. speed of the gas at 800 K will be

(1) $\frac{v_0}{4}$ (2) v_0 (3) $2v_0$ (4) $2v_0$

NTA Ans. (3)

Reso Ans. (3)

Sol. $C_{rms} = \sqrt{\frac{3RT}{m_0}} \Rightarrow C_{rms} = \propto \sqrt{T}$

$C_{rms} \propto \sqrt{4}$ times = 2 times

51. A beam of light consisting of two wavelengths 7000 and 5500 Å is used to obtain interference pattern in Young's double slit experiment. The distance between the slits is 2.5 mm and the distance between the plane of slits and the screen is 150 cm. The least distance from the central fringe, where the bright fringes due to both the wavelengths coincide, is $n \times 10^{-5}$ m. The value of n is_____.

NTA Ans. 462

Reso Ans. 462

Sol. $n_1\lambda_1 = n_2\lambda_2$

$n_1 \times 70 = n_2 \times 55$

So $n_1 = 11$ and $n_2 = 14$

$$x = n_1 \times \frac{\lambda_1 D}{d} = \frac{11 \times 7 \times 10^{-7} \times 15}{0.25} = 462 \times 10^{-5} \text{ m}$$

52. Experimentally it is found that 12.8 eV energy is required to separate a hydrogen atom into a proton and an electron. So the orbital radius of the electron in a hydrogen atom is $9/x \times 10^{-10}$ m. The value of the x is : _____ (1eV = 1.6×10^{-19} J , $\frac{1}{4\pi \in_0} = 9 \times 10^9$ Nm^2/C^2 and electronic charge = 1.6×10^{-19}C)

Ans. 16

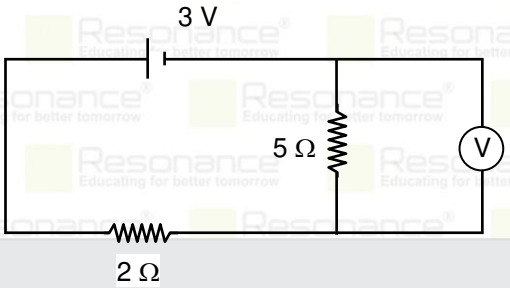
Sol. $\frac{Ke^2}{2r} = 12.8 \text{ eV}$

$\frac{Ke}{2r} = 12.8$

$$r = \frac{9 \times 10^9 \times 1.6 \times 10^{-19}}{2 \times 12.8} = \frac{9 \times 10^{-10}}{16} \text{m}$$

$x = 16$

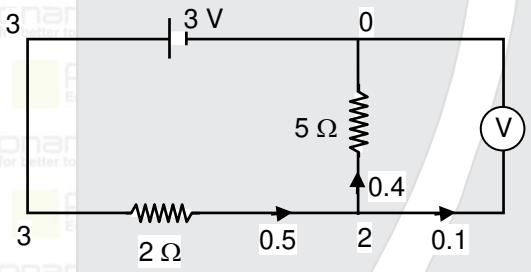
53. As shown in the figure, the voltmeter reads 2V across 5Ω resistor. The resistance of thee voltmeter is_____Ω.



NTA Ans. 20

Reso Ans. 20

Sol.



Current in 2Ω resistance is = $\frac{3-2}{2} = \frac{1}{2} = 0.5$

Current in 5Ω resistance is = $\frac{2-0}{5} = \frac{2}{5} = 0.4$

So current in voltmeter = 0.5 – 0.4

= 0.1 A

So for voltmeter V = iR

$\Rightarrow$ = 0.1 × R $\Rightarrow$ R = 20 Ω

54. A metal block of mass m is suspended from a rigid support through a metal wire of diameter 14 mm. The tensile stress developed in the wire under equilibrium state is 7×10^5 Nm^{-2}. The value of mass m is_____kg. (Take, g = 9.8 ms^{-2} and $\pi = 22/7$)

NTA Ans. 11

Reso Ans. 11

Sol. tensile stress $\sigma = \frac{mg}{\pi r^2} = \frac{4mg}{\pi d^2}$;

$m = \frac{\sigma \pi d^2}{4g} = 11$ kg

55. A body is dropped on ground from a height 'h_1' and after hitting the ground, it rebounds to a height 'h_2'. If the ratio of velocities of the body just before and after hitting ground is 4, then percentage loss in kinetic energy of the body is $\frac{x}{4}$. The value of x is ——

NTA Ans. 375

Reso Ans. 375

Sol. $\frac{\sqrt{2gh_1}}{\sqrt{2gh_2}} = 4$

$h_1 = 16h_2$

percentage loss in kinetic energy $= \frac{mg(h_1 - h_2)}{mgh_1} \times 100 = \frac{x}{4}$

$x = 375$

56. A ring and a solid sphere rotating about an axis passing through their centres have same radii of gyration. The axis of rotation is perpendicular to place of ring. The ratio of radius of ring to that of sphere is $\sqrt{\frac{2}{x}}$. The value of x is ——

NTA Ans. 5

Reso Ans. 5

Sol. $MR_1^2 = MK^2$

$\frac{2}{5} MR_2^2 = MK^2$

$\therefore R_1^2 = \frac{2}{5} R_2^2$

$\frac{R_1}{R_2} = \sqrt{\frac{2}{5}}$

57. A proton with a kinetic energy of 2.0 eV moves into a region of uniform magnetic field of magnitude $\frac{\pi}{2} \times 10^{-3}$T. The angle between the direction of magnetic field and velocity of proton is 60º. The pitch of the helical path taken by the proton is —— cm. (Take, mass of proton = 1.6×10^{-27} kg and Charge on proton = 1.6×10^{-19}C).

NTA Ans. 40

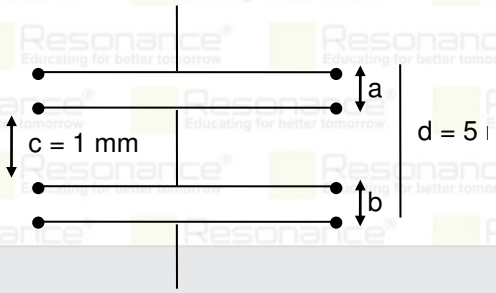
Reso Ans. 40

Sol. Pitch = $V\cos\theta$ (T)

$= V\cos\theta \frac{2\pi m}{qB}$

$= \sqrt{\frac{2E_k}{m}} \cos\theta \frac{2\pi m}{qB} = 0.4$ m = 40 cm

58. As shown in the figure, two parallel plate capacitors having equal plate area of 200 cm^2 are joined in such a way that $a \neq b$. The equivalent capacitance of the combination is $x \in_0$ F. The value of x is ——



NTA Ans. 5
Reso Ans. 5

Sol. $$C = \frac{C_1C_2}{C_1 + C_2}$$

$$= \frac{\frac{\in_0 A}{a} \times \frac{\in_0 A}{b}}{\in_0 A\left[\frac{1}{a} + \frac{1}{b}\right]} = \frac{\in_0 A}{a+b} = \frac{\in_0 \times 200 \times 10^{-4}}{4 \times 10^{-3}} = 5 \in_0 F$$

59. Two concentric circular coils with radii 1 cm and 1000 cm, and number of turns 10 and 200 respectively are placed coaxially with centres coinciding. The mutual inductance of this arrangement will be ____ $\times 10^{-8}$ H.

NTA Ans. 4
Reso Ans. 4

Sol. $\phi = MI$

$$IM = (N_1)\ \frac{m_0 N_2 I}{2R_2}(\pi R_1^2)$$

$$M = \frac{m_0 N_1 N_2 \pi R_1^2}{2R_2} = \frac{4\pi \times 10^{-7} \times 10 \times 200 \times \pi \times (.01)^2}{2 \times 10} \qquad = 4 \times 10^{-4} \times 10^{-4} = 4 \times 10^{-8} H$$

60. A simple pendulum with length 100 cm and bob of mass 250 g is executing S.H.M. of amplitude 10 cm. The maximum tension in the string is found to be $\frac{x}{40}$ N. The value of x is ——

NTA Ans. 99
Reso Ans. 99

Sol. $$T = 2\pi\sqrt{\frac{\ell}{g}} = \frac{2\pi}{\omega_n} \Rightarrow \omega_n = \sqrt{\frac{g}{\ell}} = \sqrt{\frac{10}{1}} = \sqrt{10}\ \text{rad/sec.}$$

$$V_{max} = \omega A = \sqrt{\frac{g}{\ell}}\, A$$

$$T_{max} = mg + \frac{mV_{max}^2}{\ell} = m\left(g + \frac{v_{max}^2}{\ell}\right) = mg\left(1 + \frac{A^2}{\ell^2}\right)$$

$$T_{max} = 0.25 \times 9.8\left(1 + \frac{0.01}{1}\right) = 98.98\,N \approx 99$$