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JEE (Main)

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

2023

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 13 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 ratio of powers of two motors is $\frac{3\sqrt{x}}{\sqrt{x}+1}$, that are capable of raising 300 kg water in 5 minutes and 50 kg water in 2 minutes respectively from a well of 100 m deep. The value of x will be

(1) 4 (2) 2 (3) 16 (4) 2.4

NTA Ans. (3)

Reso. Ans. (3)

Sol. $P = \frac{\text{Work}}{\text{Time(in sec)}}$

$$\frac{P_1}{P_2} = \frac{\frac{300\times10\times100}{5\times60}}{\frac{50\times10\times100}{2\times60}} = \frac{80}{25} = \frac{12}{5} = \frac{3\sqrt{16}}{\sqrt{16}+1}$$

$x = 16$

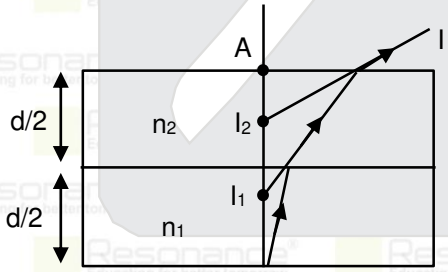
32. A vessel of depth 'd' is half filled with oil of refractive index n_1 and the other half is filled with water of refractive index n_2. The apparent depth of this vessel when viewed from above will be-

(1) $\frac{d(n_1+n_2)}{2n_1n_2}$ (2) $\frac{dn_1n_2}{2(n_1+n_2)}$ (3) $\frac{2d(n_1+n_2)}{n_1n_2}$ (4) $\frac{dn_1n_2}{(n_1+n_2)}$

NTA Ans. (1)

Reso. Ans. (1)

Sol.



$$AI_1 = \frac{d/2}{n_1} + \frac{d/2}{n_2} = \frac{d}{2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)$$

33. Which of the following Maxwell's equation is valid for time varying conditions but not valid for static condition :

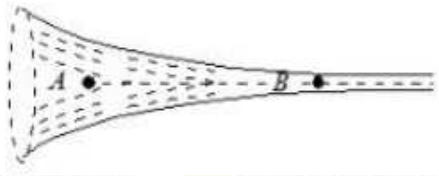
(1) $\oint\vec{B}.\overrightarrow{d\ell} = -\frac{\partial\phi_B}{\partial t}$ (2) $\oint\vec{E}.\overrightarrow{d\ell} = -\frac{\partial\phi_B}{\partial t}$ (3) $\oint\vec{E}.\overrightarrow{dI} = 0$ (4) $\oint\vec{D}.\overrightarrow{dA} = Q$

NTA Ans. (2)

Reso. Ans. (2)

Sol. It is theoretical based on Ampere's circuit law.

34.



The figure shows a liquid of given density flowing steadily in horizontal tube of varying cross-section. Cross sectional areas at A is 1.5 cm^2, and B is 25 mm^2, if the speed of liquid at B is 60 cm/s then (PA – PB) is:

(Given PA and PB are liquid pressures at A and B points, density p = 1000 kg m^{-3})

A and B are on the axis of tube

(1) 175 Pa (2) 135 Pa (3) 27 Pa (4) 36 Pa

NTA Ans. (1)

Reso. Ans. (1)

Sol. We have Bernoulli's equation

$$P+\frac{1}{2}\rho v^2+\rho gh=\text{constant}$$

$$P_A-P_B=\frac{\rho}{2}\left(v_B^2-v_A^2\right) \quad .....(1)$$

We have

$A_Av_A = A_Bv_B$

$$v_A=\frac{A_Bv_B}{AA}=\frac{(25\,mm^2)(60\,cm/s)}{1.5m^2}$$

$$=\frac{(25mm^2)(60\,cm/s)}{(105)(100)mm^2}$$

$$=\frac{60\ cm/s}{6}=10\,cm/s=\frac{10}{100}m/s=\frac{1}{10}m/s$$

$$v_B=60\,cm/s=\frac{60}{100}m/s=\frac{6}{10}m/s$$

putting in equation (1)

$$P_A-P_B=\left(\frac{1000km}{2m^3}\right)\left(\frac{36}{100}-\frac{1}{100}\right)m/s=\frac{1000}{x}\times\frac{35}{100}=175$$

35. Two bodies are having kinetic energies in the ratio 16 : 9. If they are same linear momentum, the ratio of their masses respectively is :

(1) 16 : 9 (2) 4 : 3 (3) 3 : 4 (4) 9 : 16

NTA Ans. (4)

Reso. Ans. (4)

Sol. $k = \frac{p^2}{2m}$

$$\frac{k_2}{k_1} = \frac{m_1}{m_2}$$

$$\frac{9}{16} = \frac{m_1}{m_2} \Rightarrow \frac{m_1}{m_2} = \frac{9}{16}$$

36. The source of time varying magnetic field may be

(A) a permanent magnet

(B) an electric field changing linearly with time

(C) direct current

(D) a decelerating charge particle

(E) an antenna fed with a digital signal

Choose the correct answer from the options given below:

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

NTA Ans. (3)

Reso. Ans. (3)

Sol. A decelerating charge has variable velocity (i.e. time varying velocity) hence its magnetic field is also dependent on time.

37. The difference between threshold wavelengths for two metal surfaces A and B having work function ϕ_A = 9 eV and ϕ_B = 4.5 eV in nm is: {Given, hc = 1242 eV nm}

(1) 540 (2) 276 (3) 264 (4) 138

NTA Ans. (4)

Reso. Ans. (4)

Sol. $\phi = \frac{hc}{\lambda_{th}}$

$$\Rightarrow \lambda_{th} = \frac{hc}{\phi}$$

So difference of λ_{th} is

$$= \frac{1242}{4.5} - \frac{1242}{9} = 1242\left[\frac{1}{4.5} - \frac{1}{9}\right]$$

$$= 1242\left[\frac{2}{9} - \frac{1}{9}\right] = \frac{1242}{9} = 138$$

38. A planet having mass 9 M_e and radius $4R_e$ where M_e and R_e are mass and radius of earth respectively, has escape velocity in km/s given by: (Given escape velocity on earth $V_e = 11.2 \times 10^3$ m/s)

(1) 16.8 (2) 33.6 (3) 11.2 (4) 67.2

NTA Ans. (1)

Reso. Ans. (1)

Sol. $v_e = \sqrt{\frac{2GM}{R}}$

$v'_e \sqrt{\frac{2G \times 9m}{4R}} = \frac{3}{2} v_e$

39. A body of mass (5 ± 0.5) kg is moving with a velocity of (20 ± 0.4) m/s. Its kinetic energy will be

(1) (1000 ± 0.14) J (2) (500 ± 140) J (3) (1000 ± 140) J (4) (500 ± 0.14) J

NTA Ans. (3)

Reso. Ans. (3)

Sol. $K = \frac{1}{2}mv^2 = \frac{1}{2}(5)(20)^2 = 1000$

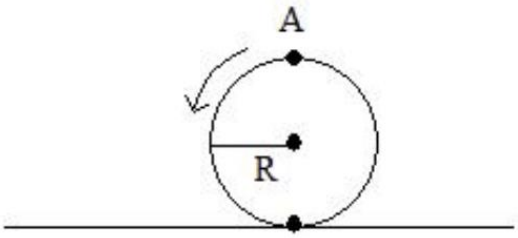
again $K = \frac{1}{2}mv^2$

$\frac{dK}{K} = \frac{dm}{m} + \frac{2dv}{v}$

$= \frac{0.5}{5} + \frac{2(0.4)}{20} = \frac{1}{10} + \frac{4}{100} = \frac{14}{100}$

$dK = K\left(\frac{14}{100}\right) = (1000)\left(\frac{14}{100}\right) = 140$

40. A disc is rolling without slipping on a surface. The radius of the disc is R. At t = 0, the top most point on the disc is A as shown in figure. When the disc completes half of its rotation, the displacement of point A from its initial position is

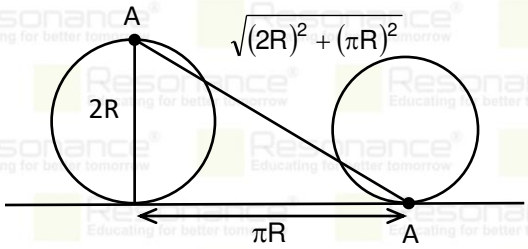


(1) $R\sqrt{(\pi^2+1)}$ (2) $R\sqrt{(\pi^2+4)}$ (3) $2R\sqrt{(1+4\pi^2)}$ (4) 2R

NTA Ans. (2)

Reso. Ans. (2)

Sol.



Displacement = $R\sqrt{\pi^2+4}$

41. Two trains 'A' and 'B' of length 'i' and '4ℓ' are travelling into a tunnel of length 'L' in parallel tracks from opposite directions with velocities 108 km/h and 72 km/h, respectively. If train 'A' takes 35s less time than train 'B' to cross the tunnel then, length 'L' of tunnel is : (Given L = 60 ℓ)

(1) 1800 m (2) 900 m (3) 2700 m (4) 1200 m

NTA Ans. (1)

Reso. Ans. (1)

Sol. According to question

$$\frac{64\ell}{20}-\frac{61\ell}{30}=35$$

$\Rightarrow \ell = 30$ m

So, $L = 60\ell = 60 \times 30 = 1800$ m

42. Under isothermal condition, the pressure of a gas is given by $P = aV^{-3}$, where a is a constant and V is the volume of the gas. The bulk modulus at constant temperature is equal to

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

NTA Ans. (3)

Reso. Ans. (3)

Sol. $pv^3 = \text{Constant} \Rightarrow \frac{dp}{p}+3\frac{dv}{v}=0 \Rightarrow \frac{dp}{dv}=-3\frac{p}{v}$

$$B=-v\frac{dP}{dv}=-(v)\left(-3\frac{p}{v}\right)$$

$B = 3P$

43.

List –I (Layer of atmosphere)		List–II (Approximate height over earth's surface	
(A)	F_1 – Layer	(I)	10 km
(B)	D–Layer	(II	170 – 190 km
(C)	Troposphere	(III)	100 km
(D)	E – Layer	(IV)	65 – 75 km

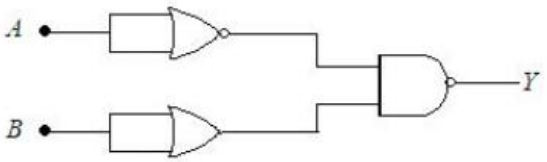
Choose the correct answer from the options given below :

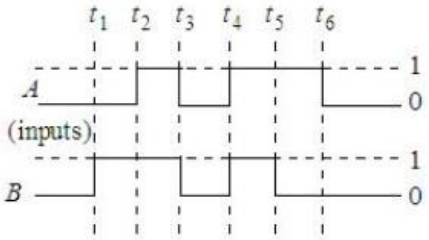
(1) A–III, B–IV, C–I, D–II (2) A–II, B–IV, C–III, D–I

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

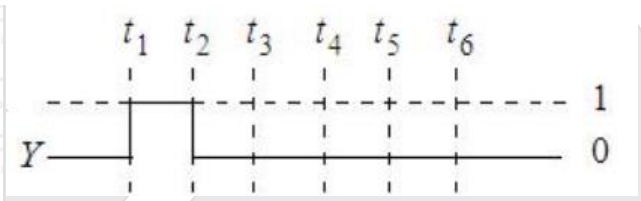
NTA Ans. (4)
Reso. Ans. (4)
Sol. Purely theoretical direct theory based

44. For the following circuit and given inputs A and B, choose the correct option for output 'I'

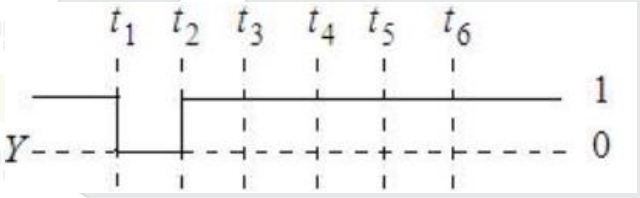




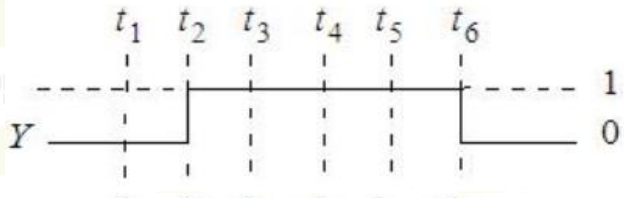
(1)



(2)



(3)

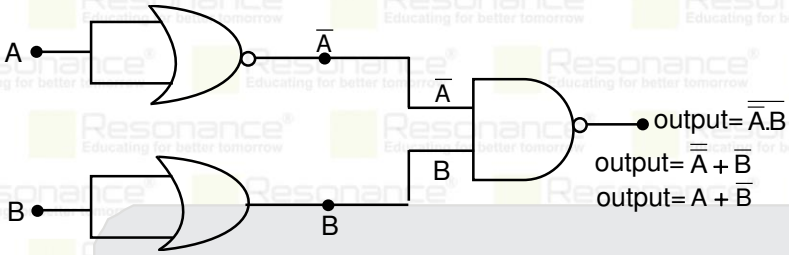


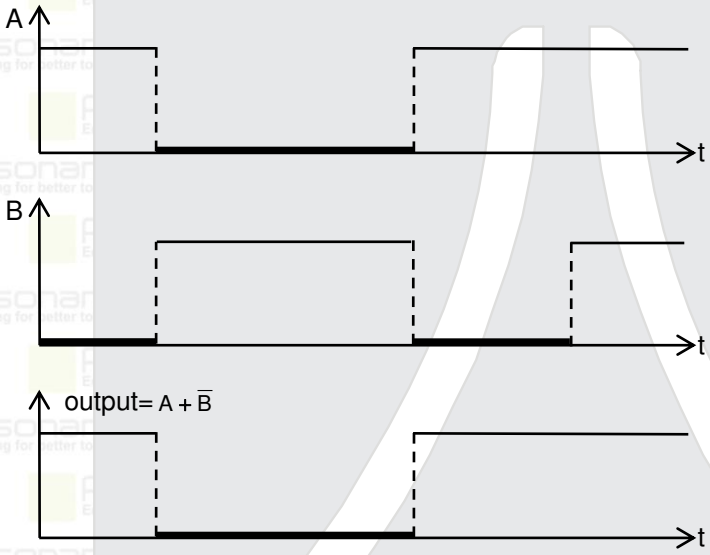
(4)

NTA Ans. (2)

Reso. Ans. (2)

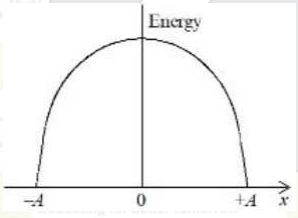
Sol.



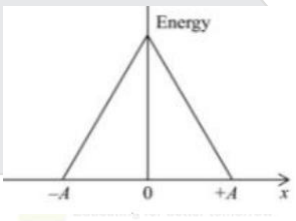


45. Which graph represents the difference between total energy and potential energy of a particle executing SHM vs it's distance from mean position ?

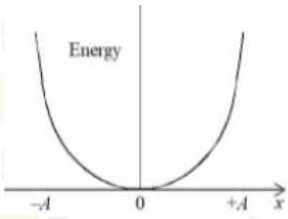
(1)



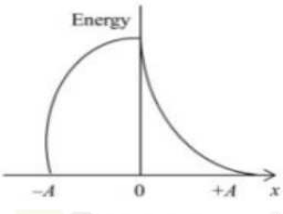
(2)



(3)



(4)

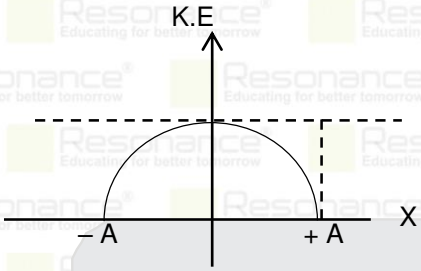


NTA Ans. (1)

Reso. Ans. (1)

Sol. TE – P.E = K.E

$K.E = K = \frac{1}{2}mv^2 = \frac{1}{2}m.\omega^2(A^2 - x^2)$



46. The rms speed of oxygen molecule in a vessel at particular temperature is $\left(1+\frac{5}{x}\right)^{1/2}$ v, where v is the average speed of the molecule. The value of x will be : (Take $\pi = \frac{22}{7}$)

(1) 27 (2) 8 (3) 4 (4) 28

NTA Ans. (4)

Reso. Ans. (4)

Sol. $v_{RMS} = \left(1+\frac{5}{x}\right)^{\frac{1}{2}} v_{av}$

$$\sqrt{\frac{3RT}{M}} = \sqrt{\left(1+\frac{5}{x}\right)}\sqrt{\frac{8RT}{\pi M}}$$

$$\sqrt{3} = \sqrt{\left(1+\frac{5}{x}\right)\left(\frac{8}{\pi}\right)}$$

$$\Rightarrow \frac{5}{x} = \frac{3\pi}{8} - 1 = \frac{3\pi - 8}{8}$$

$$x = \frac{40}{3\pi - 8} \approx 28$$

47. Two charges each of magnitude 0.01 C and separated by a distance of 0.4 mm constitute an electric dipole. If the dipole is placed in an uniform electric field $\vec{E}$ of 10 dyne/C making 30° angle with $\vec{E}$, the magnitude of torque acting on dipole is :

(1) 4.0×10^{-10} Nm (2) 1.0×10^{-8} Nm (3) 2.0×10^{-10} Nm (4) 1.5×10^{-9} Nm

NTA Ans. (3)

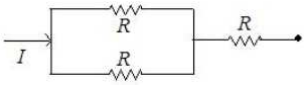
Reso. Ans. (3)

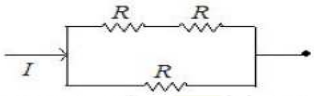
Sol. $\tau = PE\sin\theta$ $P = 0.01 \times 0.4 \times 10^{-3}$

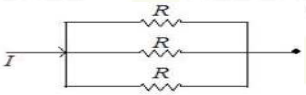
$= 0.4 \times 10^{-5}$

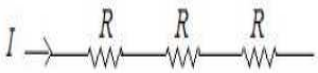
$\tau = 0.4 \times 10^{-5} \times 10 \times 10^{-5} \times 1/2 = \tau = 2 \times 10^{-10}$ N–m

48. Different combination of 3 resistors of equal resistance R are shown in the figures. The increasing order for power dissipation is :

(A) 

(B) 

(C) 

(D) 

(1) $P_B < P_C < P_D < P_A$

(2) $P_A < P_B < P_C < P_D$

(3) $P_C < P_D < P_A < P_B$

(4) $P_C < P_B < P_A < P_D$

NTA Ans. (4)

Reso. Ans. (4)

Sol. For fixed value of current $P \propto R$

more is equivalent resistance more is the power

$R_D > R_A > R_B > R_C$

$P_D > P_A > P_B > P_C$

49. A bullet of 10g leaves the barrel of gun with a velocity of 600 m/s. If the barrel of gun is 50 cm long and mass of gun is 3 kg, then value of impulse supplied to the gun will be :

(1) 12 Ns (2) 6 Ns (3) 3 Ns (4) 36 Ns

NTA Ans. (2)

Reso. Ans. (2)

Sol. By momentum conservation

$0 = 3(-v) + (0.01)(600 - v)$

$v = 2$ m/s

Impulse suplied to gun = (3 kg) (2 m/s)

= 6 Ns

50. $^{238}_{92}A \rightarrow {}^{234}_{90}B + {}^{4}_{2}D + Q$

In the given nuclear reaction, the approximate amount of energy released will be :

[Given, mass of $^{238}_{92}A = 238.05079 \times 931.5$ MeV/e^2, mass of $^{234}_{90}B = 234.04363 \times 931.5$ MeV/e^2,

Mass of $^{4}_{2}B = 4.00260 \times 931.5$ MeV/e^2]

(1) 3.82 MeV (2) 2.12 MeV (3) 4.25 MeV (4) 5.9 MeV

NTA Ans. (3)

Reso. Ans. (3)

Sol. $\Delta m_{loss} = (238.029) - (234.021 + 4.003)$

$\Delta m_{loss} = 0.005$ amu

Energy released = $(931 \times \Delta m)$ MeV

$= 931 \times 0.005 = 4.65$ MeV

51. When a resistance of 5Ω is shunted with a moving coil galvanometer, it shows a full scale deflection for a current of 250 mA, however when 1050 Ω resistance is connected with it in series, it givens full scale deflection for 25 volt. The resistance of galvenometer is :

NTA Ans. 50

Reso. Ans. 50

Sol. $R \rightarrow$ Resistance of galvenometer

$r_s \rightarrow$ Resistance of series connected

Full scale deflection is 25 V

$i_g(R + r_s) = 25$

$$i_g = \frac{25}{R+1050} \qquad .....(1)$$

We also have another relation for current in galvanometer which is

$i_gR + i_gr_p = 250 \times 10^{-3}\, r_p$ {r_p = shunt resistance

$$i_g = \frac{(0.25)r_p}{R+r_p} \qquad .....(2)$$

From (1) and (2)

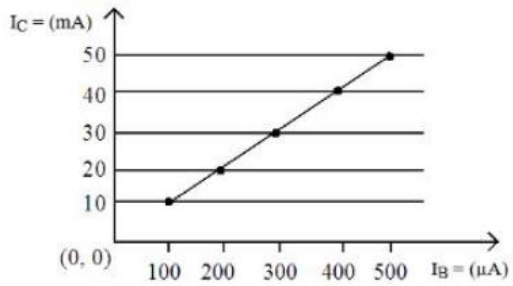
$$\frac{25}{R+1050} = \frac{(0.25)(5)}{R+5}$$

$100\,R + 500 = 5R + 5250$

$95R = 4750$

$$R = \frac{4750}{95} = 50\,\Omega$$

52. From the given transfer characteristic of a transistor in CE configuration, the value of power gain of this configuration is 10^x, for R_B = 10 kΩ, and R_C = 1kΩ. The value of x is _____



NTA Ans. 3
Reso. Ans. 3

Sol. $$V_{gain} = \left(\frac{\Delta i_c}{\Delta i_b}\right)\frac{R_{out}}{R_{in}} = \left(\frac{40\times10^{-3}\,A}{400\times10^{-6}\,A}\right)\frac{R_{out}}{R_{in}} = (100)\frac{R_{out}}{R_{in}}$$

$$P_{gain} = \left(\frac{\Delta i_c}{\Delta i_b}\right)V_{gain} = \left(\frac{40\times10^{-3}}{400\times10^{-6}}\right)(100)\frac{R_{out}}{R_{in}}$$

$$(100)(100)\frac{R_{out}}{R_{in}} = (10^4)\left(\frac{1}{10}\right) = 10^3 \Rightarrow \quad x = 3 \quad [\text{Note : } R_{out} = R_C,\ R_{in} = R_B]$$

53. A thin infinite sheet charge and an infinite line charge of respective charge densities + σ and +λ are placed parallel at 5 m distance from each other. Points 'P' and 'Q' are at $\frac{3}{\pi}$ m and $\frac{4}{\pi}$m perpendicular distances from line charge towards sheet charge, respectively. 'E_p' and 'E_q' are the magnitudes of resultant electric field intensities at point 'P' and 'Q', respectively. If $\frac{E_P}{E_Q}=\frac{4}{a}$ for $|2\sigma| = |\lambda|$, then the value of a is

NTA Ans. (6)

Reso. Ans. (6)

54. The radius of 2nd orbit of He^+ of Bohr's model is r_1 and that of fourth orbit of Be^{3+} is represented as r_2. Now the ration $\frac{r_2}{r_1}$ is x : 1. The value of x is _____

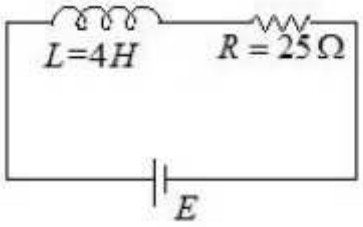
NTA Ans. (2)

Reso. Ans. (2)

Sol. We have $r = a_0\frac{n^2}{2}$

$$\frac{r_2}{r_1}=\frac{4^2}{2^2}\times\frac{2}{4}=\frac{4}{2}=2$$

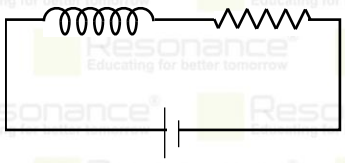
55. In the given figure, an inductor and a resistor are connected in series with a battery of emf E volt. $\frac{E^\theta}{2b}$J/s represents the maximum rate at which the energy is stored in the magnetic field (inductor). The numerical value of $\frac{b}{a}$ will be ____



NTA Ans. (25)

Reso. Ans. (25)

Sol.



$\mathbf{i = i_0 (1-e^{-t/2})}$

$\frac{di}{dt} = \frac{10}{2} e^{-t/2}$

$P = Li\frac{di}{dt} = Li_0\ \mathbf{(1-e^{-t/2})}\ \frac{i_0}{2} e^{-t/2}\ \left(z = \frac{L}{R}\right)$

$P = i_0^2 R\,(1 - e^{-t/2})(e^{-t/2})$

from maxima and minima

P_{max} obtained when $e^{-t/2} = \frac{1}{2}$

So, $P_{max} = i_0^2 R\left(1-\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{i_0^2 R}{4} = \frac{E^2}{4R} = \frac{E^4}{2b}$

$a = 2$

$2b = 4R \Rightarrow b = 2R = 50$

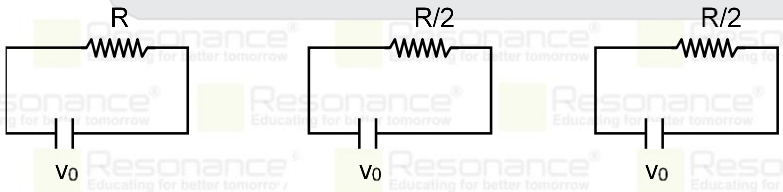
$\frac{b}{a} = \frac{50}{2} = 25$

56. A potential V_0 is applied across a uniform wire of resistance R. The power dissipation is P_1. The wire is then cut into two equal halves and a potential of V_0 is applied across the length of each half. The total power dissipation across two wires is $P_2 : P_1$ is $\sqrt{x} : 1$. The value of x is _____

NTA Ans. (16)

Reso. Ans. (16)

Sol.



$P_1 = \frac{v_0^2}{R}$ $\qquad P_2 = \frac{2v_0^2}{R} + \frac{2v_0^2}{R} = \frac{4v_0^2}{R}$

$\frac{P_2}{P_1} = \frac{4}{1} = \frac{\sqrt{16}}{1} = \frac{\sqrt{x}}{1}$

$x = 16$

57. A fish rising vertically upward with a uniform velocity of 8 ms^{-1}, observes that a bird is diving vertically downward towards the fish with the velocity of 12 ms^{-1}. If the refractive index of water is, then the actual velocity of the diving bird to pick the fish, will be _____ms^{-1}

NTA Ans. (3)

Reso. Ans. (3)

Sol. $v = v_{Fish} + \frac{(v_{Bird})\mu_{water}}{\mu_{air}}$

$12 = 8 + (v_{Bird})\frac{4}{3}$

$4 = (v_{Bird})\frac{4}{3}$

$v_{Bird} = 3$ m/s

58. A solid sphere is rolling on a horizontal plane without slipping. If the ratio of angular momentum about axis of rotation of the sphere to the total energy of moving sphere is $\pi : 22$, then, the value of its angular speed will be _____rad/s.

NTA Ans. (4)

Reso. Ans. (4)

Sol. $\frac{\text{Angular momentum}}{\text{Total energy}} = \frac{\text{Angular momentum}}{\text{Total kinetic energy}}$

$\frac{I_w}{\frac{1}{2}mv^2 + \frac{1}{2}Iw^2} = \frac{\pi}{22}$

$\frac{\frac{2}{5}mR^2.w}{\frac{1}{2}\left(mw^2R^2 + \frac{2}{5}mR^2w^2\right)} = \frac{\pi}{22}$

$\frac{\frac{4}{5}mR^2w}{\frac{7}{5}\left(mR^2w^2\right)} = \frac{\pi}{22}$

$\frac{4}{7w} = \frac{22}{7 \times 22} = \frac{1}{7}$

$w = 4$ rad/s.

59. The elastic potential energy stored in a steel wire of length 20 m stretched through 2 cm is 80 J. The cross sectional area of the wire is _____mm^2. (Given, y = 2.0 × 10^{11} Nm^{-2})

NTA Ans. (40)

Reso. Ans. (40)

Sol. P.E. per unit volume in stretched wire = μ

$= \frac{1}{2}$ (stress)(strain)

Total P.E. = μ(volume)

$80J = \frac{1}{2}$ (stress)(strain)(volume)

$80J = \frac{1}{2}(Y)(\text{strain})^2$ (volume)

$$80J = \frac{1}{2}\left(2\times10^{11}\,\frac{M}{m^2}\right)\left(\frac{\Delta\ell}{\ell}\right)^2 A\ell$$

$$80J = \left(10^{11}\,\frac{M}{m^2}\right)\frac{\left(2\times10^{-2}\right)^2}{20m}A$$

$$80 = 10^{11}\times\frac{10^{-4}}{5}A$$

$$A = \frac{400}{10^7}m^2$$

$A = 40 \times 10^{-6}$ m^2

$A = (40)(10^{-6})(10^6)$ mm^2

$A = 40$ mm^2

60. At a given point of time the value of displacement of a simple harmonic oscillator is given as y = A cos (30°). If amplitude is 40 cm and kinetic energy at that time is 200 J, the value of force constant is 1.0 × 10^x Nm^{-1}. The value of x is _____

NTA Ans. (4)

Reso. Ans. (4)

Sol. $y = \frac{A\sqrt{3}}{2}$

$A = 0.4$ m

$$E_K = 200\,J = \frac{1}{2}mw^2\left(A^2 - y^2\right)$$

$$400J = mw^2\left(A^2 - \frac{3A^2}{4}\right)$$

$$400J = mw^2\left(\frac{A^2}{4}\right)$$

$mw^2 = 10^4$

$K = 10^4$

$x = 4$