CollegeDekho

FINAL JEE–MAIN EXAMINATION – APRIL, 2023

(Held On Thursday 13th April, 2023) **TIME : 9 : 00 AM to 12 : 00 NOON**

SECTION-A

31. Which of the following Maxwell's equations is valid for time varying conditions but not valid for static conditions :

(1) $\oint \vec{B}.\vec{dl} = \mu_0 I$ (2) $\oint \vec{E}.\vec{dl} = 0$

(3) $\oint \vec{E}.\vec{dl} = -\frac{\partial \phi_B}{\partial t}$ (4) $\oint \vec{D}.\vec{dA} = Q$

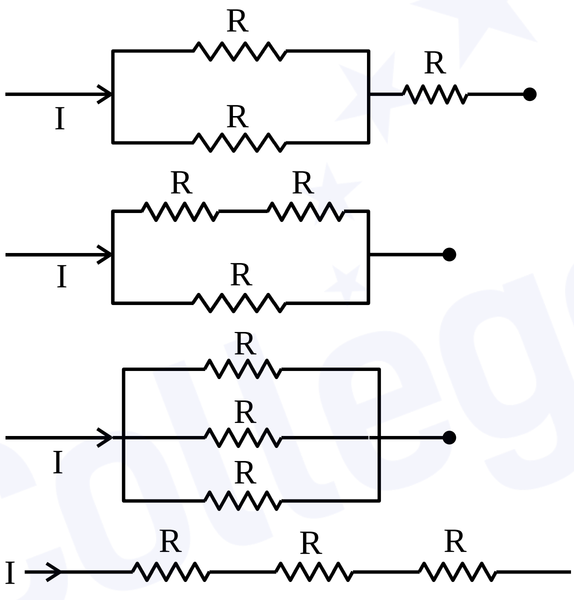
Official Ans. by NTA (3)

Ans. (3)

Sol. Based on equations of Maxwell

32. 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) $P_A < P_B < P_C < P_D$

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

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

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

Official Ans. by NTA (4)

Ans. (4)

Sol. $P = I^2R$

$$R_1 = \frac{3R}{2}, R_2 = \frac{2R}{3}, R_3 = \frac{R}{3}, R_4 = 3R$$

Since i is same, hence $P \alpha R$ so options (4) is correct

33. 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) $\frac{d\, n_1 n_2}{(n_1 + n_2)}$

(2) $\frac{d(n_1 + n_2)}{2n_1 n_2}$

(3) $\frac{d\, n_1 n_2}{2(n_1 + n_2)}$

(4) $\frac{2d(n_1 + n_2)}{n_1 n_2}$

Official Ans. by NTA (2)

Ans. (2)

Sol. Formula used $d_{app} = \frac{d_1}{n_1} + \frac{d_2}{n_2}$

$$d_{app} = \frac{d}{2}\left[\frac{n_1 + n_2}{n_1 n_2}\right]$$

34. 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) (D) only

(2) (C) and (E) only

(3) (A) only

(4) (B) and (D) only

Official Ans. by NTA (1)

Ans. (1)

Sol. Source of time varying magnetic field may be

$\rightarrow$accelerated or retarded charge which produces varying electric and magnetic fields.

$\rightarrow$ An electric field varying linearly with time will not produce variable magnetic field as current will be constant

35. Two trains 'A' and 'B' of length 'l' 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) 1200 m

(2) 2700 m

(3) 1800 m

(4) 900 m

Official Ans. by NTA (3)

Ans. (3)

Sol. $\frac{60\ell+4\ell}{20}-\frac{61\ell}{30}=35$

$\Rightarrow \ell=\frac{1050}{35}$

$\Rightarrow L=60\ell=\frac{1050}{35}\times 60=1800\text{ m}$

36. 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) 2

(2) 4

(3) 2.4

(4) 16

Official Ans. by NTA (4)

Ans. (4)

Sol. Average Power = $\frac{\textit{total work done}}{\textit{total time}}$

So $P=\frac{mgh}{t}$

$$\frac{P_1}{P_2}=\frac{\frac{m_1gh}{t_1}}{\frac{m_2gh}{t_2}}=\frac{m_1}{t_1}\frac{t_2}{m_2}$$

$$\frac{P_1}{P_2}=\frac{300\times 2}{5\times 50}=\frac{12}{5}=\frac{3\sqrt{x}}{\sqrt{x}+1}$$

$$12\sqrt{x}+12=15\sqrt{x}$$

$$3\sqrt{x}=12$$

$$x=16$$

37. A planet having mass 9 Me and radius $4R_e$, where Me and Re 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) 67.2

(2) 16.8

(3) 33.6

(4) 11.2

Official Ans. by NTA (2)

Ans. (2)

Sol. $V_P=\sqrt{\frac{2GM_P}{R_P}}$ $V_E=\sqrt{\frac{2GM_E}{R_E}}$

$$\frac{V_P}{V_E}=\frac{\sqrt{\frac{2GM_P}{R_P}}}{\sqrt{\frac{2GM_E}{R_E}}}=\sqrt{\frac{R_E}{R_P}\times\frac{M_P}{M_E}}$$

$$V_P=\sqrt{\frac{1}{4}\times 9}\times V_E=\frac{3}{2}V_E$$

$$V_P=\frac{3}{2}\times 11.2\text{ km/sec}$$

$$=16.8\text{ km/sec}$$

38. The difference between threshold wavelengths for two metal surfaces A and B having work function $\phi_A=9\text{eV}$ and $\phi_B=4.5\text{eV}$ in nm is:

(Given, hc = 1242 eV nm)

(1) 264

(2) 138

(3) 276

(4) 540

Official Ans. by NTA (2)

Ans. (2)

Sol. $\lambda_A=\left(\frac{1242}{9}\right)=138\text{ nm}$

$$\lambda_B=\left(\frac{1242}{4.5}\right)=276\text{ nm}$$

$$\lambda_B-\lambda_A=138\text{ nm}$$

39. A bullet 10 g 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) 36 Ns (4) 3 Ns

Official Ans. by NTA (2)

Ans. (2)

Sol. By momentum conservation

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

$v \simeq 2 m/s$

Impulse on gun $= 3 \times 2 = 6$ Ns

40. 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 30^0 angle with $\vec{E}$, the magnitude of torque acting on dipole is :

(1) 4.0×10^{-10} Nm (2) 2.0×10^{-10} Nm

(3) 1.0×10^{-8} Nm (4) 1.5×10^{-9} Nm

Official Ans. by NTA (2)

Ans. (2)

Sol. $|\vec{P}| = qd$

$$= 0.01 \times 0.4 \times 10^{-3}$$

$$= 4 \times 10^{-6}$$

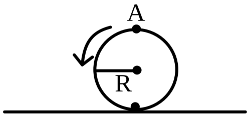
$$|\vec{\tau}| = PE \sin\theta$$

$$= 4 \times 10^{-6} \times 10 \times 10^{-5} \times \sin 30$$

$$= 4 \times 10^{-6-5+1} \times \frac{1}{2}$$

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

41. 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



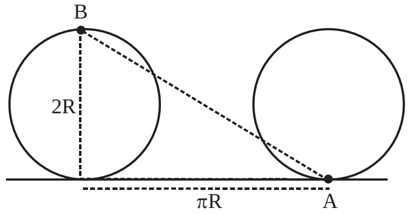
(1) $R\sqrt{(\pi^2 + 4)}$ (2) $R\sqrt{(\pi^2 + 1)}$

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

Official Ans. by NTA (1)

Ans. (1)

Sol.



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

42. Match List – I with List – II

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

Official Ans. by NTA (4)

Ans. (4)

Sol. Based on Theory

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

(1) 28

(2) 27

(3) 8

(4) 4

Official Ans. by NTA (1)

Ans. (1)

Sol. $\sqrt{\frac{3RT}{M}} = \left(1 + \frac{5}{x}\right)^{\frac{1}{2}} \sqrt{\frac{8RT}{\pi M}}$

$$\Rightarrow \frac{3 \times 22}{7 \times 8} = 1 + \frac{5}{x}$$

$$\Rightarrow x = 28$$

44. 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 ± 140) J

(2) (1000 ± 0.14) J

(3) (500 ± 0.14) J

(4) (500 ± 140) J

Official Ans. by NTA (1)

Ans. (1)

Sol. $k = \frac{1}{2}mv^2$

$k = \frac{1}{2} \times 5 \times 400 = 5 \times 200 = 1000\text{ J}$

$\frac{\Delta k}{2k} = \frac{\Delta m}{m} + \frac{2\,\Delta v}{v} = \frac{0.5}{5} + \frac{2 \times 0.4}{20}$

$\Delta k = 1000\left(\frac{1}{10} + \frac{4}{100}\right) = 1000\left(\frac{10+4}{100}\right) = 140\text{ J}$

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

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

(3) 16 : 9 (4) 9 : 16

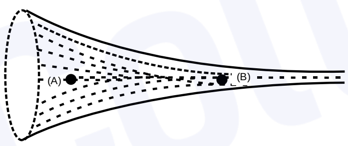
Official Ans. by NTA (4)

Ans. (4)

Sol. $\frac{K_1}{K_2} = \frac{p_1^2}{2m_1} \times \frac{2m_2}{p_2^2} = \frac{m_2}{m_1} = \frac{16}{9}$

$\frac{\quad}{m_2} = \frac{9}{16}$

46.



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 $(P_A - P_B)$ is :

(Given P_A and P_B are liquid pressures at A and B points.

Density $\rho = 1000\text{ kg m}^{-3}$

A and B are on the axis of tube

(1) 175 Pa

(2) 27 Pa

(3) 135 Pa

(4) 36 Pa

Official Ans. by NTA (1)

Ans. (1)

Sol. From continuity theorem $A_1V_1 = A_2V_2$

$1.5 \times V_1 = 25 \times 10^{-2} \times 60$

$V_1 = \frac{25 \times 60 \times 10^{-2} \times 10}{1.5}$

$V_1 = 10\text{ cm/s}$

By Bernoulli's theorem

$P_1 + \frac{1}{2} \times 1000 \times (0.1)^2 = P_2 + \frac{1}{2} \times 1000 \times (0.6)^2$

$P_1 + 5 = P_2 + \frac{1}{2} \times 1000 \times 36 \times 10^{-2}$

$P_1 + 5 = P_2 + 180$

$P_1 - P_2 = 175\text{ Pa}$

47. 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) 3 P

(3) 2 P (4) P

Official Ans. by NTA (2)

Ans. (2)

Sol. $B = -\frac{dP}{dv/v}$

$Pv^3 = a$

Differentiating w.r.t to pressure

$v^3 + P3v^2\frac{dv}{dP} = 0$

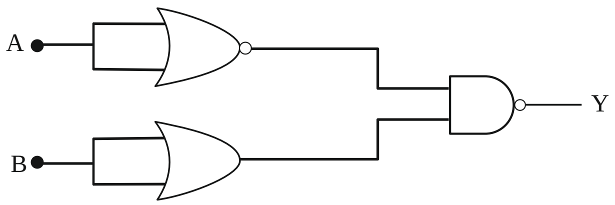
$v = -3\frac{Pdv}{dP} = 0$

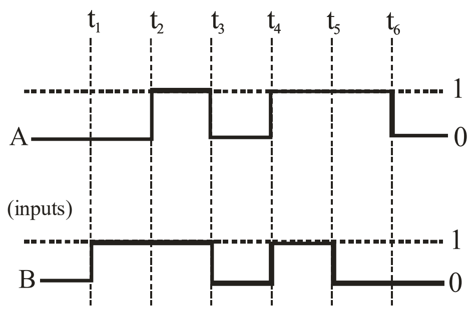
$v = -3\frac{Pdv}{dP}$

$\frac{dP.v}{dv} = -3P$

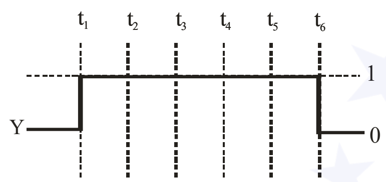
$B = -\left(\frac{dPv}{dv}\right) = -(-3P) = 3P$

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





(1)



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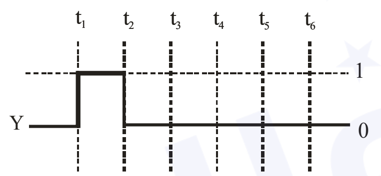
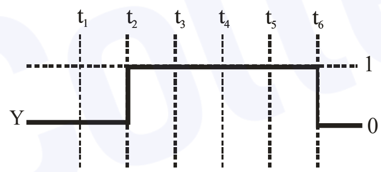
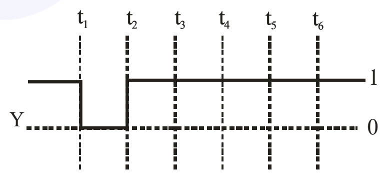


(3)



(4)



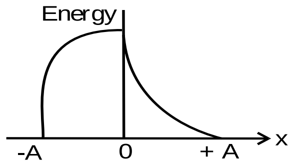
Official Ans. by NTA (4)

Ans. (4)

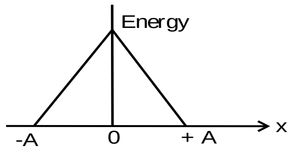
Sol. $Y = \overline{\overline{A} \cdot B} = A + \overline{B}$

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

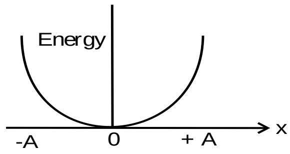
(1)



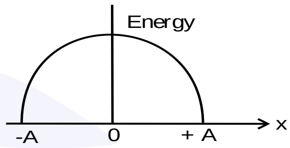
(2)



(3)



(4)



Official Ans. by NTA (4)

Ans. (4)

Sol. T.E. – P.E. = K.E.

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

Which is the equation of downward parabola.

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 $^{238}_{92}A = 238.05079 \times 931.5\ \text{MeV}/c^2$,

mass of $^{234}_{90}B = 234.04363 \times 931.5\ \text{MeV}/c^2$,

mass of $^{4}_{2}D = 4.00260 \times 931.5\ \text{MeV}/c^2$]

(1) 3.82 MeV (2) 5.9 MeV

(3) 2.12 MeV (4) 4.25 MeV

Official Ans. by NTA (4)

Ans. (4)

Sol. $Q = \left(m_A - m_B - m_D\right) \times 931.5\ MeV$

$$= (238.05079 - 234.04363 - 4.00260) \times 931.5$$

$$\Rightarrow 4.25\ Mev$$

Section - B

51. 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, $y = 2.0\times10^{11}\,Nm^{-2}$)

Official Ans. by NTA (40)

Ans. (40)

Sol. Energy per unit volume $= \frac{1}{2} stress \times strain$

$$\text{Energy} = \frac{1}{2} stress \times strain \times volume$$

$$80 = \frac{1}{2} \times Y \times strain^2 \; A \times \ell$$

$$80 = \frac{1}{2} \times 2\times10^{11} \times \frac{\left(2\times10^{-2}\right)^2}{400} \times A \times 20$$

$$20 = \frac{10^{+7}}{20} \times A$$

$$40\times10^{-6}\, m^2 = A$$

$$A = 40\, mm^2$$

52. 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. The ratio $P_2 : P_1$ is $\sqrt{x} : 1$. The value of x is __________.

Official Ans. by NTA (16)

Ans. (16)

Sol. $P = VI = I^2R = \frac{V^2}{R}$

Now $R = \frac{\rho l}{A}$

If wire is cut in two equal half

$$R' = \frac{R}{2}$$

Initial $P_1 = \frac{V_0^2}{R}$

After $P_2 = \frac{V_0^2}{R'} \times 2 \Rightarrow \frac{V_0^2}{R} \times 4$

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

$$x = 16$$

53. At a given point of time the value of displacement of a simple harmonic oscillator is given as $y = A\cos(30^0)$. If amplitude is 40 cm and kinetic energy at that time is 200 J, the value of force constant is $1.0\times10^{x}\,Nm^{-1}$. The value of x is __________.

Official Ans. by NTA (4)

Ans. (4)

Sol. General equation for displacement is given by

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

at given time

$$\Rightarrow \omega t + \phi = 30^0$$

$$\Rightarrow x = 40 \times \frac{\sqrt{3}}{2} \Rightarrow 20\sqrt{3}\, cm$$

$$\Rightarrow A = 40\, cm$$

$$\Rightarrow K.E = \frac{1}{2}k\left(A^2 - x^2\right) = 200$$

$$200 = \frac{1}{2}k\left(\frac{1600-1200}{100\times100}\right)$$

$$400\times100\times100 = k\times400$$

$$k = 10^4$$

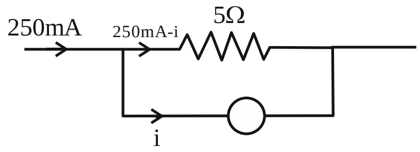
$$x = 4$$

54. 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 $1050\,\Omega$ resistance is connected with it in series, it gives full scale deflection for 25 volt. The resistance of galvanometer is __________ Ω.

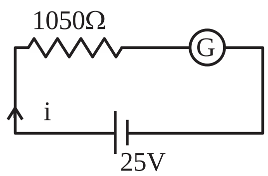
Official Ans. by NTA (50)

Ans. (50)

Sol.



$$\frac{250\ mA\times 5}{5+R_G}=i \qquad \text{........ (i)}$$



$$i=\frac{25}{1050+R_G} \qquad \text{........ (ii)}$$

From (i) and (ii)

$$\frac{25}{1050+R_G}=\frac{5}{4(5+R_G)}$$

$$100(5+R_G)=1050\times5+R_G\times5$$

$$95\ R_G=4750$$

$$R_G=50\Omega$$

55. 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 ratio $\frac{r_2}{r_1}$ is x : 1. The value of x is ___________

Official Ans. by NTA (2)

Ans. (2)

Sol. $r\propto\frac{n^2}{z}$

$$\frac{r_{He^+}}{r_{Be}} \quad \frac{2^2\times4}{\times4\times4}=\frac{1}{2}$$

56. A thin infinite sheet charge and an infinite line charge of respective charge densities $+\sigma$ and $+\lambda$ 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 distance 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 ____________.

Official Ans. by NTA (6)

Ans. (6)

Sol. $E_A=\frac{\lambda}{2\pi\varepsilon_0 r_A}-\frac{\sigma}{2\varepsilon_0}\left\{r_A=\frac{3}{\pi}\right\}$

$$=\frac{1}{2\varepsilon_0}\left[\frac{\lambda}{3}-\sigma\right]$$

$$E_B=\frac{\lambda}{2\pi\varepsilon_0 r_A}-\frac{\sigma}{2\varepsilon_0}\left\{r_B=\frac{4}{\pi}\right\}$$

$$=\frac{1}{2\varepsilon_0}\left[\frac{\lambda}{4}-\sigma\right]$$

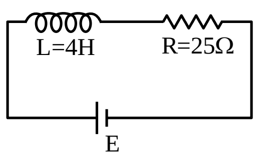
$$\frac{E_A}{E_B}=\frac{4}{3}\left(\frac{\lambda-3\sigma}{\lambda-4\sigma}\right)$$

$$=\frac{4}{3}\left[\frac{2\sigma-3\sigma}{2\sigma-4\sigma}\right]$$

$$=\frac{4}{3}\left[\frac{-\sigma}{-2\sigma}\right]$$

$$=\frac{4}{6}$$

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



Official Ans. by NTA (25)

Ans. (25)

Sol. $E = \frac{1}{2}LI^2$

Rate of energy storing $= \frac{dE}{dt} = LI\frac{dI}{dt}$

Now we Know for $R-L$ circuit

$I = \frac{E}{R}\left(1-e^{-t\frac{R}{L}}\right)$

So $\frac{dI}{dt} = \frac{E}{L}e^{-\frac{tR}{L}}$

$\frac{dE}{dt} = \frac{E^2}{R}\left(1-e^{-\frac{tR}{L}}\right)\left(e^{-t\frac{R}{L}}\right)$

Time at which rate of power storing will be max,

$t = \frac{L}{R\ln 2}$

So $\frac{dE}{dt} = \frac{E^2}{R}\left(1-\frac{1}{2}\right)\times\frac{1}{2}$

$\Rightarrow \frac{E^2}{4R} = \frac{E^2}{100} = \frac{E^2}{2\times 50}$

$a = 2, b = 50$

So $\frac{b}{a} = 25$

58. 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 $\frac{4}{3}$, then the actual velocity of the diving bird to pick the fish, will be __________ ms^{-1}.

Official Ans. by NTA (3)

Ans. (3)

Sol. $\frac{V_{b/f}}{\frac{4}{3}} = \frac{-8}{\frac{4}{3}} + \frac{(-v)}{1}$

$\Rightarrow \frac{}{3} \quad \frac{-8}{\frac{4}{3}} + \frac{(-v)}{1}$

$\Rightarrow v = 3\,m/s$

59. 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.

Official Ans. by NTA (4)

Ans. (4)

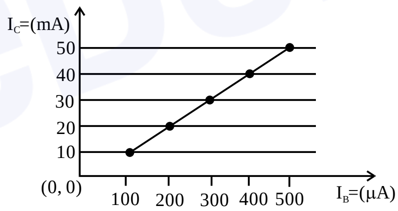
Sol. $L = (I_{com})(\omega)$ and $K = \frac{1}{2}(I_{com})(\omega^2) + \frac{1}{2}MV_{com}^2$

$L = \frac{2}{5}MR^2\frac{V_{com}}{R}$ $\quad K = \frac{1}{2}\left(\frac{2}{5}MR^2\right)\frac{V_{com}^2}{R^2} + \frac{1}{2}MV_{com}^2$

$L = \frac{2MRV_{com}}{5}$ $\quad K = \frac{7}{10}MV_{com}^2$

Ratio $\frac{L}{K} = \frac{4}{7}\frac{R}{V_{com}} = \frac{\pi}{22} \Rightarrow \omega = \frac{4}{7}\times\frac{22}{22}\times 7 = 4$

60. From the given transfer characteristic of a transistor in CE configuration, the value of power gain of this configuration is 10^x, for $R_B = 10\,k\Omega$, and $R_C = 1\,k\Omega$. The value of x is __________.



Official Ans. by NTA (3)

Ans. (3)

Sol. Power gain

$\Rightarrow A_V . A_I = B\frac{R_C}{R_B} . B = B^2\frac{R_C}{R_B}$

$= \left(\frac{(20-10)\times 10^{-3}}{(200-100)\times 10^{-6}}\right)\times\frac{1\times 10^3}{10\times 10^3} = 10^3$

Hence $x = 3$