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JEE (Main)

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

2023

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 11 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

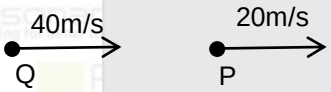
31. A car P travelling at 20 ms^{-1} sounds its horn at a frequency of 400 Hz. Another car Q is travelling being the first car in the same direction with a velocity 40 ms^{-1}. The frequency heard by the passenger of the car Q is approximately [Take, velocity of sound = 360 ms^{-1}]

(1) 485 Hz (2) 421 Hz (3) 471 Hz (4) 514 Hz

NTA Ans. (2)

Reso Ans. (2)

Sol.



$$f^1 = f\left[\frac{v+40}{v+20}\right]$$

$$f^1 = 400\left[\frac{360+40}{360+20}\right]$$

= 421 Hz

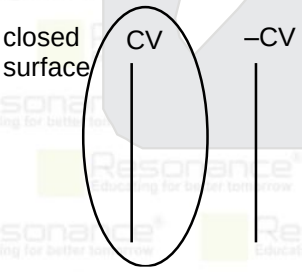
32. A capacitor of capacitance C is charged to a potential V. The flux of the electric field through a closed surface enclosing the positive plate of the capacitor is :

(1) $\frac{CV}{2\varepsilon_0}$ (2) $\frac{2CV}{\varepsilon_0}$ (3) Zero (4) $\frac{CV}{\varepsilon_0}$

NTA Ans. (1)

Reso Ans. (1)

Sol.



Charge on capacitor q = CV

charge on positive plate will be q = +CV

So flux passing through the closed surface is $\phi = \frac{q_{in}}{\varepsilon_0}$

$= \frac{CV}{\varepsilon_0}$

33. A plane electromagnetic wave of frequency 20 MHz propagates in free space along x-direction. At a particular space and time, $\vec{E} = 6.6\hat{j}\,V/m$. What is $\vec{B}$ at this point ?

(1) $-2.2 \times 10^{-}\,\hat{i}\,T$ (2) $-2.2 \times 10^{-8}\,\hat{k}\,T$ (3) $2.2 \times 10^{-8}\,\hat{i}\,T$ (4) $2.2\times 10^{-8}\,\hat{k}\,T$

NTA Ans. (4)

Reso Ans. (4)

Sol. In EM wave

$E = CB$

$\therefore B = \frac{E}{C}$

$B = \frac{6.6}{3\times10^{8}}$

$= 2.2 \times 10^{-8}$ T

Direction of $\vec{B}$ is along $\hat{k}$

$\therefore \vec{B}Z = 2.22 \times 10^{-8}\,\hat{k}\,T$

34. The energy of He^{+} ion in its first excited state is, (The ground state energy for the Hydrogen atom is –13.6 eV) :

(1) –13.6 eV (2) –3.4 eV (3) –54.4 eV (4) –27.2 eV

NTA Ans. (1)

Reso Ans. (1)

Sol. $E = -\frac{Z^2}{n^2}(13.6)\,eV = -\frac{2^2}{2^2}(13.6)\,eV = -13.6$ eV.

35. If force (F), velocity (V) and time (T) are considered as fundamental physical quantity, then dimensional formula of density will be :

(1) $F^2V^{-2}T^6$ (2) FV^4T^{-6} (3) $FV^{-2}T^2$ (4) $FV^{-4}T^{-2}$

NTA Ans. (4)

Reso Ans. (4)

Sol. $\rho \propto F^x V^y T^z$

$[ML^{-3}] = [MLT^{-2}]^x [LT^{-1}]^y [T]^z$

$= M^xL^{x+y} T^{-2x-y+z}$

So, $x = 1$

$x + y = -3 \Rightarrow 1 + y = -3 \Rightarrow y = -4$

$-2x - y + z = 0 \Rightarrow -2 + 4 + z = 0$

$\Rightarrow z = -2.$

36. An electron is allowed to move with constant velocity along the axis of current carrying straight solenoid.

A. The electron will experience magnetic force along the axis of the solenoid.

B. The electron will not experience magnetic force.

C. The electron will continue to move along the axis of the solenoid.

D. The electron will be accelerated along the axis of the solenoid.

E. The electron will follow parabolic path-inside the solenoid.

Choose the correct answer from the options given below :

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

NTA Ans. (3)

Reso Ans. (3)

Sol. B is along axis of solenoid and velocity of electron is also along axis of solenoid

$\therefore$ Magnetic force = – e $\left(\vec{V}\times\vec{B}\right)$

= eVB sin0

= 0

acceleration of electron = 0

So e^- do not experience magnetic force and continue t_0 move along axis of solenoid

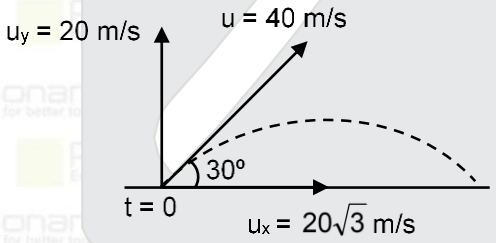
37. A projectile is projected at 30° from horizontal with initial velocity 40 ms^{-1}. The velocity of the projectile at t = 2s from the start will be : (given g = 10 m/s^2)

(1) $40\sqrt{3}$ m/s^{-1} (2) $20\sqrt{3}$ m/s^{-1} (3) 20 m/s^{-1} (4) zero

NTA Ans. (2)

Reso Ans. (2)

Sol.



After time t = 2 sec

$v_x = u_x + a_x.t = 20\sqrt{3}$

$v_y = u_y + a_y\, t = 20 + (-10) \times 2 = 0$

$\therefore \vec{v} = v_x\hat{i} + v_y\hat{j} = 20\sqrt{3}\,\hat{i}\,m/s$

38. The root mean square speed of molecules of nitrogen gas at 27°C is approximately : (Given mass of a nitrogen molecule = 4.6×10^{-26} kg and take Boltzmann constant $K_B = 1.4 \times 10^{-23}$ JK^{-1})

(1) 1260 m/s (2) 91 m/s (3) 27.4 m/s (4) 523 m/s

NTA Ans. (4)

Reso Ans. (4)

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$

$= \sqrt{\frac{3RT}{m \times NA}}$

$= \sqrt{\frac{3RT}{M}}$

$= \sqrt{\frac{3 \times 1.4 \times 10^{-23} \times 300}{4.6 \times 10^{-26}}} = 523 \text{ m/s}$

39. The Thermodynamics process, in which internal energy of the system remains constant is :

(1) isochoric (2) Isobaric (3) Adiabatic (4) Isothermal

NTA Ans. (4)

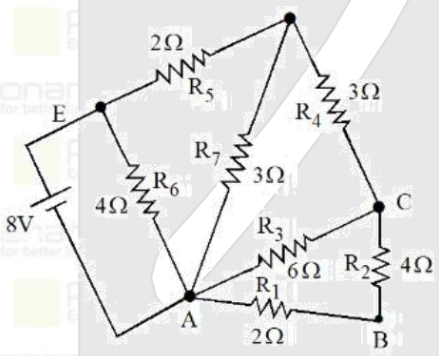
Reso Ans. (4)

Sol. $\Delta U = \frac{f}{2} nR\Delta t$

In isothermal process temperature remain constant so $\Delta U = 0$

$\therefore$ internal energy remain constant

40.



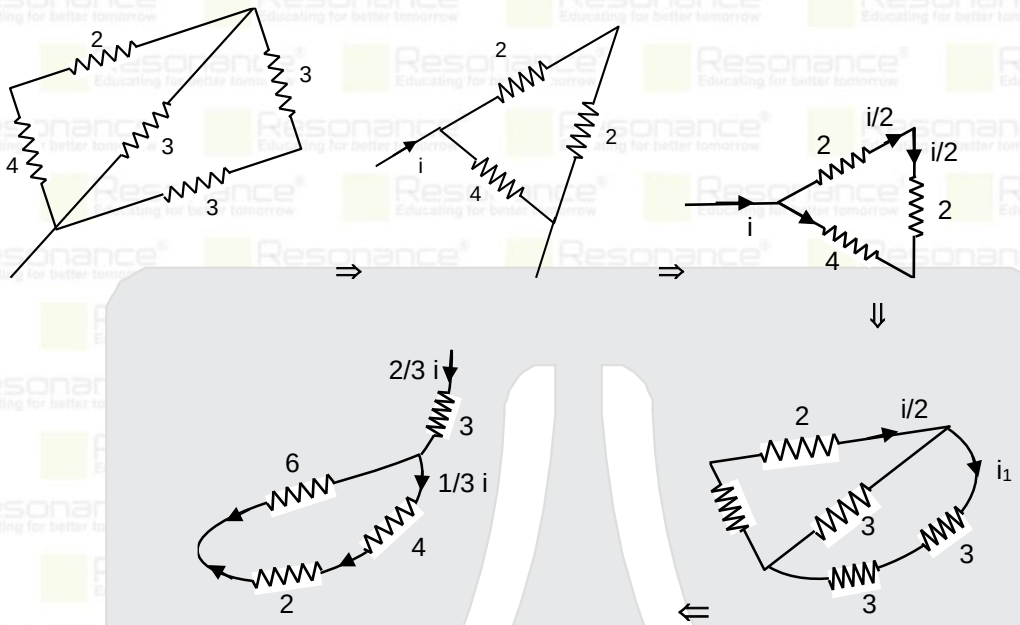
The current flowing through R_2 is

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

NTA Ans. (1)

Reso Ans. (1)

Sol.



$$i = \frac{8}{R_{eq}} = \frac{8}{2} = 4$$

$$i_1 = \frac{3}{3+6} \times \frac{i}{2} = \frac{3}{9} \times \frac{4}{2} \Rightarrow \frac{2}{3}$$

current through R_2 is $\frac{i_1}{2} = \frac{1}{3}$ Amp

41. In satellite communication, the uplink frequency band used is :

(1) 76 – 88 MHz (2) 3.7 – 4.2 GHz (3) 5.925 – 6.425 GHz (4) 420 – 890 MHz

NTA Ans. (3)

Reso Ans. (3)

42. A body of mass 500 g moves along x-axis such that it's velocity varies with displacements x according to the relation $v = 10\sqrt{x}$ m/s the force acting on the body is :

(1) 25 N (2) 125 N (3) 5 N (4) 166 N

NTA Ans. (1)

Reso Ans. (1)

Sol. $a = v\frac{dv}{dx}$

$a = 10\sqrt{x} \times 10 \times \frac{1}{2\sqrt{x}}$

$a = 50$

$\Rightarrow f = ma \therefore f = \frac{500}{1000} \times 50 \Rightarrow 25N$

43. Eight equal drops of water are falling through air with a steady speed of 10 cm/s. If the drops coalesce, the new velocity is :

(1) 5 cm/s (2) 40 cm/s (3) 16 cm/s (4) 10 cm/s

NTA Ans. (2)

Reso Ans. (2)

Sol. $V_{Terminal} \propto r^2$

$\frac{4\pi r^3 \times 8}{3} = \frac{4\pi r^3}{3}$ (Volume conservation)

$R = 2r$

$\therefore$ V new become 4 times

$\therefore$ new velocity = 40 cm/s

44. If V is he gravitational potential due to sphere of uniform density on its' surface, then it's value at the center of sphere will be :

(1) V (2) 3V/2 (3) 4/3 V (4) V/2

NTA Ans. (2)

Reso Ans. (2)

Sol. $V_{surface} = \frac{-GM}{R} = V$

$V_{centre} = \frac{-3}{2}\frac{GM}{R}$

$\Rightarrow \frac{3v}{2}$

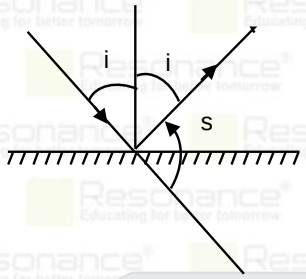
45. When one light ray is reflected from a plane mirror with 30° angle of reflection, the angle of deviation of the ray after reflection is :

(1) 140° (2) 110° (3) 120° (4) 130°

NTA Ans. (3)

Reso Ans. (3)

Sol.



$i = 30^o$

$s = 180 - 2i = 180 - 2\times 30 = 120^o$

46. The ratio of the de-Broglie wavelengths of proton and electron having same Kinetic energy : (Assume $m_p = m_e \times 1849$)

(1) 2:43 (2) 1:30 (3) 1:43 (4) 1:62

NTA Ans. (3)

Reso Ans. (3)

Sol. $\lambda = \dfrac{h}{\sqrt{2mKE}} \Rightarrow \lambda \propto \dfrac{1}{\sqrt{m}}$

$$\frac{\lambda_p}{\lambda_e} = \sqrt{\frac{m_e}{m_p}} = \sqrt{\frac{1}{1849}} = \frac{1}{43}$$

47. A space slip of mass 2×10^4 kg is launched into a circular orbit close to the earth surface. The additional velocity to be imparted to the space ship in the orbit to overcome the gravitational pull will be (if $g = 10\ m/s^2$ and radius of earth = 6400 km)

(1) $11.2\ (\sqrt{2}-1)$ km/s (2) $7.9(\sqrt{2}-1)$ km/s (3) $8(\sqrt{2}-1)$ km/s (4) $7.4(\sqrt{2}-1)$ km/s

NTA Ans. (3)

Reso Ans. (2)

Sol. Initial velocity = $\sqrt{\dfrac{GM}{R}}$

escape speed = $\sqrt{\dfrac{2GM}{R}} = 11.2$ km/s

Additional= $\sqrt{\dfrac{2GM}{R}} - \sqrt{\dfrac{GM}{R}}$

$= (\sqrt{2}-1)\sqrt{\dfrac{GM}{R}}$

$= (\sqrt{2}-1)\dfrac{11.2}{\sqrt{2}} = 7.9\ (\sqrt{2}-1)$ km/s

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

Assertion (A): A bar magnet dropped through a metallic cylindrical pipe takes more time to come down compared to a non-magnetic bar with same geometry and mass.

Reason (R) : For the magnetic bar, Eddy currents are produced in the metallic pipe which oppose the motion of the magnetic bar.

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

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

(2) A is false but R is true

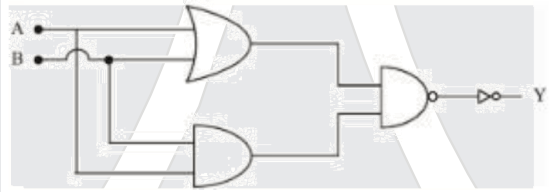
(3) Both A and R are true but R is NOT the correct explanation of A

(4) A is true but R is false

NTA Ans. (1)

Reso Ans. (1)

49. The logic operations performed by the given digital circuit is equivalent to :

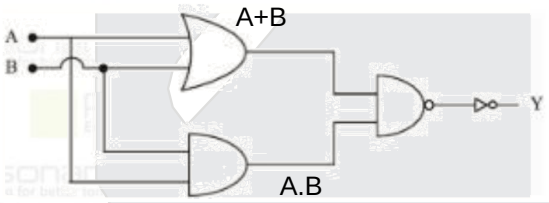


(1) NAND (2) NOR (3) AND (4) OR

NTA Ans. (3)

Reso Ans. (3)

Sol.



A	B	Y
1	0	0
0	1	0
0	0	0
1	1	1

AND GATE

50. When vector $\vec{A} = 2\hat{i} + 3\hat{j} + 2\hat{k}$ is subtracted from vector $\vec{B}$, it gives a vector equal to $2\hat{j}$. Then the magnitude of vector $\vec{B}$ will be :

(1) $\sqrt{6}$ (2) $\sqrt{5}$ (3) 3 (4) $\sqrt{13}$

NTA Ans. (3)

Reso Ans. (3)

Sol. $\vec{A} - \vec{B} = 2\hat{j}$

$\vec{B} = \vec{A} - 2\hat{j}$

$\vec{B} = 2\hat{i} + 3\hat{j} + 2\hat{k} - 2\hat{j}$

$\Rightarrow 2\hat{i} + \hat{j} + 2\hat{k}$

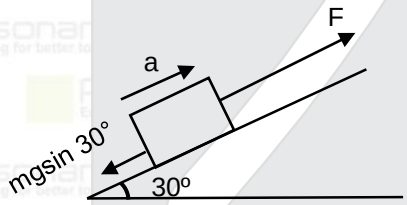
$|\vec{B}| = \sqrt{2^2 + 1 + 2^2} = 3$

51. A block of mass 5 kg starting from rest pulled up on a smooth incline plane making an angle of 30° with horizontal with an affective acceleration of 1 ms^{-2}. The power delivered by the pulling force at t = 10 s from the start is ____ W. [Use g = 10 ms^{-2}] (Calculate the nearest integer value)

NTA Ans. 300

Reso Ans. 300

Sol.



$\Rightarrow$ v = u + at

$\therefore$ Vat t = 10 $\Rightarrow$ at

$= 1 \cdot 10$

$\Rightarrow$ 10 m/s

$f - 5 \times 10 \sin 30^\circ = 5 \times 1$

f = 30N

p = f Vcos 0°

= 30 × 10= 300

52. A coil has an inductance of 2H and resistance of 4W, A 10V is applied across the coil. The energy stored in the magnetic field after the current has built up to its equilibrium value will be ____ $\times 10^{-2}$ J.

NTA Ans. (625)

Reso Ans. (625)

Sol. $u = \frac{1}{2}Li^2$

At steady state $\hat{i} = \frac{E}{R}$

$\hat{i} = \frac{10}{4} = \frac{5}{2}$

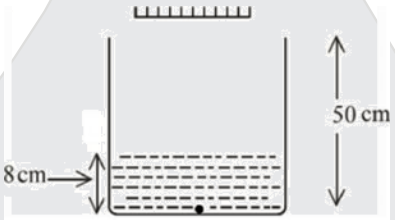
$u = \frac{1}{2} \times 2 \times \frac{25}{4}$

$u = \frac{25}{4} = 6.25$

$= 625 \times 10^{-2}$ J

= 625 Ans.

53. As shown in the figure, a plane mirror is fixed at a height of 50 cm from the bottom of tank containing water (μ = 4/3). The height of water is the tank is 8 cm. A small bulb is placed at the bottom of the water tank. The distance of image of the bulb formed by mirror from the bottom of the tank is ____cm.



NTA Ans. (98)

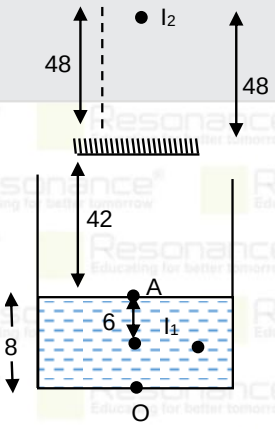
Reso Ans. (98)

Sol. $AI_1 = \frac{A_0}{4/3} = \frac{3}{4} \times 8$

$\Rightarrow 6$ cm

distance of I_2 from bottom = 48 + 42 + 8

= 98 cm



54. A circular plate is rotating in horizontal plane, about an axis passing through its center and perpendicular to the plate, with an angular velocity ω. A person sits at the center having two dumbbells in his hands. When he stretches out his hands, the moment of inertia of the system becomes triple. If E be the initial Kinetic energy of the system, then final Kinetic energy will be E/x. The value of x is.

NTA Ans. (3)

Reso Ans. (3)

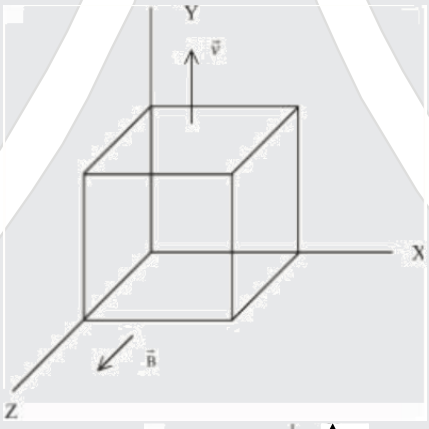
Sol. $I_1 \omega_1 = I_2 \omega_2$ (Angular momentum conserratacon)

$I_1 \omega_1 = 3I_1 \omega_2 \therefore \omega_2 = \frac{\omega_1}{3}$

$E = \frac{1}{2} I_1 \omega_1^2$

$E^1 = \frac{1}{2} 3I_1 \times \left(\frac{\omega_1}{3}\right)^2 \Rightarrow \frac{1}{2} I_1 \frac{\omega_1^2}{2} = \frac{E}{3}$ = 3 Ans.

55. A metallic cube of side 15 cm moving along y-axis at a uniform velocity of 2 ms^{-1}. In a region of uniform magnetic field of magnitude 0.5T directed along z-axis. In equilibrium the potential difference between the faces of higher and lower potential developed because of the motion through the field will be ___ mV.



NTA Ans. 150

Reso Ans. 150

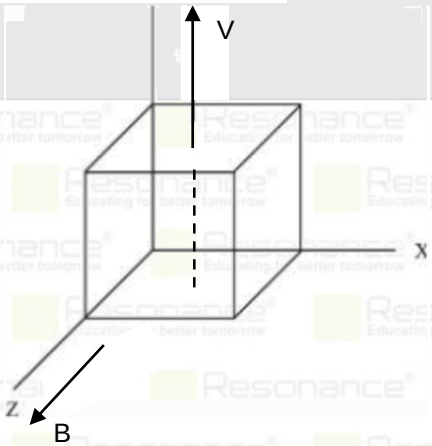
Sol. $e = BV\ell$

$= 0.5 \times 2 \times 0.15$

$= 0.15$ V

$= 15 \times 10^{-2}$V

$= 150$ mv

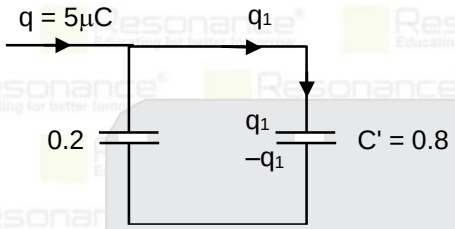


56. The surface tension of soap solution is 3.5×10^{-2} Nm^{-1}. The amount of work done required to increase the radius of soap bubble from 10 cm to 20 cm is_____$\times 10^{-4}$ J. (take $\pi = 22/7$)

NTA Ans. 264

Reso Ans. 264

Sol.



W = change in surface energy

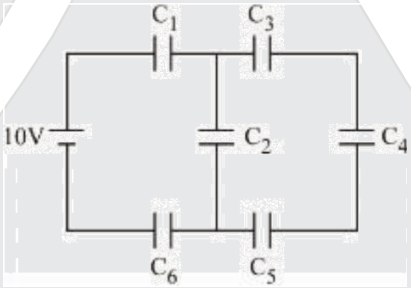
$w = 2T(A_f - A_i)$

$= \frac{2\times3.5\times10^{-2}}{10} \times \frac{22}{7} \times 4\ [0.04 - 0.01]$

$\Rightarrow 26.4 \times 10^{-3}$

$\Rightarrow 264 \times 10^{-4}$

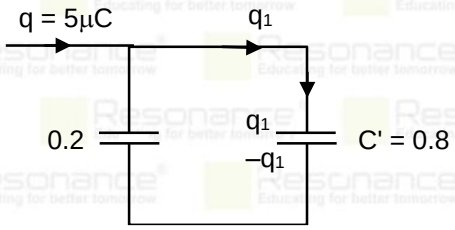
57. In the given circuit $C_1 = 2\mu F$, $C_2 = 0.2\mu F$, $C_3 = 2\mu F$, $C_4 = 4\mu F$, $C_5 = 2\mu F$, $C_6 = 2\mu F$. The charge stored on capacitor C_4 is _____ μC.



NTA Ans. 4

Reso Ans. 4

Sol.



$$\frac{1}{C_1} = \frac{1}{C_3} + \frac{1}{C_4} + \frac{1}{C_5} = \frac{1}{2} + \frac{1}{4} + \frac{1}{2} \Rightarrow \frac{2+1+2}{4}$$

$C' = \frac{4}{5}$

$C'' = C_2 + C_1 = 0.2 + \frac{4}{5} \Rightarrow 1$

$C_{eq} = \frac{1}{C_1} + \frac{1}{C^6} + \frac{1}{C''} \Rightarrow \frac{1}{2} + \frac{1}{2} + \frac{1}{1} \therefore C_{eq} = \frac{1}{2}$

$q = 10 \times C_{eq} = 10 \times \frac{1}{2} \Rightarrow 5$

$q_1 = \frac{0.8 \times 5}{0.8 + 0.2} \Rightarrow 0.8 \times 5 = 4$

58. A wire of density 8×10^3 kg/m^3 is stretched between two clamps 0.5 m apart. The extension developed in the wire is 3.2×10^{-4} m. If Y = 8×10^{10} N/m^2, the fundamental frequency of vibration in the wire will be _____Hz.

NTA Ans. 80

Reso Ans. 80

Sol. $f = \sqrt{\frac{T}{Ap}} \frac{1}{2\ell} = \sqrt{\frac{stress}{P}} \frac{1}{2\ell}$

$f = \frac{\sqrt{4 \times strain}}{P} \frac{1}{2\ell} = \sqrt{\frac{y \times \Delta\ell}{\ell P}} \frac{1}{2\ell}$

$\sqrt{\frac{8 \times 10^{10} \times 3.2 \times 10^{-4}}{0.5 \times 8 \times 10^3}} \frac{1}{2 \times 0.5} = 80$

59. A nucleus disintegrates into two nuclear parts, in such a way that ratio of their nuclear sizes is $1 : 2^{2/3}$. Their respective speed have a ratio of n : 1. The value of n is _____.

NTA Ans. 2

Reso Ans. 2

Sol. $P_i = P_f$

$O = m_1v_1 - m_2v_2$

$m_1v_1 = m_2v_2$

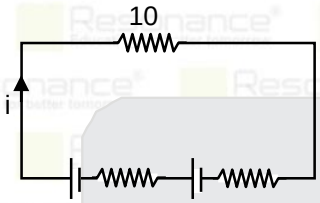
$\frac{v_1}{v_2} = \frac{m_2}{m_1} = \left(\frac{R_2}{R_1}\right)^3 = \left(\frac{2^{1/3}}{1}\right)^3 = 2 : 1$

60. Two identical cells each of emf 1.5 V are connected in series across a 10Ω resistance. An ideal voltmeter connected across 10 resistance reads 1.5 V. The internal resistance of each cell is _____Ω.

NTA Ans. 5

Reso Ans. 5

Sol.



$$i = \frac{1.5+1.5}{r+r+10} = \frac{3}{10+2r}$$

reading = i × 10

$$\frac{3\times10}{10+2r} = 1.5$$

10 + 2r = 20

r = 5