FINAL JEE–MAIN EXAMINATION – APRIL, 2023
Held On Tuesday 11th April, 2023
TIME : 03:00 PM to 06:00 PM

SECTION - A

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

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

Sol. (2)

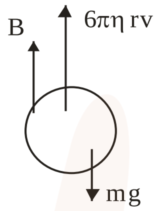
$8 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$R = 2r$

$V = \frac{2r^2}{9\eta}(\rho_b - \rho_{air})$

$V \propto r^2$

$\frac{V_1}{V_2} = \left(\frac{r}{R}\right)^2$



$\boxed{V_2 = V_1 \times 4 = 10 \times 4 = 40\ \text{km/s}^{-1}}$

32. 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 statements, choose the correct answer from the options given below

(1) A is true but R is false

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

(3) A is false but R is true

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

Sol. (4)

Due to Eddy current in the metallic pice which opposes the motion of magnetic bar. So, it takes more time to comes down compared to non-magnetic bar.

33. A space ship 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) $7.9(\sqrt{2}-1)$ km/s (2) $7.4(\sqrt{2}-1)$ km/s (3) $11.2(\sqrt{2}-1)$ km/s (4) $8(\sqrt{2}-1)$ km/s

Sol. (4)

$\Delta V = \sqrt{\frac{GM}{R}}(\sqrt{2}-1)$

$= \sqrt{\frac{GM}{R^2} \times R}(\sqrt{2}-1)$

$= \sqrt{gR}(\sqrt{2}-1) = 8000(\sqrt{2}-1)\ ms^{-1}$

$= 8(\sqrt{2}-1)\ kms^{-1}$

34. A projectile is projected at 30° from horizontal with initial velocity 40 ms^{-1}. The velocity of the projectile at t = 2 s from the start will be :

(Given $g = 10\ m/s^2$)

(1) Zero (2) $20\sqrt{3}\ ms^{-1}$ (3) $40\sqrt{3}\ ms^{-1}$ (4) $20\ ms^{-1}$

Sol. **(2)**

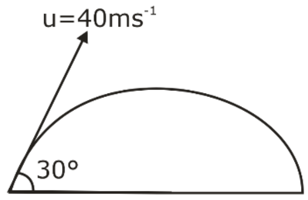
$U_x = 40 \cos 30 = 20\sqrt{3}$

$U_y = 40 \sin 30 = 20$

$Vx = 20\sqrt{3}$

$V_y = u_y - gt = 20 - 10 \times 2 = 0$

$V = \sqrt{v_x^2 + v_y^2} = 20\sqrt{3} = ms^{-1}$



35. 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) $-2.2 \times 10^{-8}\ \hat{k}\ T$ (2) $-2.2 \times 10^{-8}\ \hat{i}\ T$ (3) $2.2 \times 10^{-8}\ \hat{k}\ T$ (4) $2.2 \times 10^{-8}\ \hat{i}\ T$

Sol. **(3)**

$|B| = \frac{|E|}{C} = \frac{6.6}{3\times10^8} = 2.2 \times 10^{-8}$

For direction of $\vec{B}$

$= \vec{E}\times\vec{B} = \vec{C}$

$= \hat{j}\times\vec{B} = \hat{i}$

$\vec{B} = (2.2\times10^{-8})\hat{k}\,T$

36. A car P travelling at 20 ms^{-1} sounds its horn at a frequency of 400 Hz. Another car Q is travelling behind 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) 471 Hz (2) 514 Hz (3) 421 Hz (4) 485 Hz

Sol. **(3)**

$V_c = 20\ ms^{-1}$

f = 400 Hz

Q → = 40 ms^{-1} P → 20 ms^{-1}

0 ←⊕— S

$f_{app} = \left[\frac{Vs - (-V_Q)}{V_S - (-V_p)}\right] f$

$= \left(\frac{360+40}{360+20}\right)\times400 = \frac{400}{380} \times 400 = 421$ Hz Ans. (3)

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

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

Sol. **(1)**

$$v = 10\sqrt{x} \Rightarrow \frac{dv}{dx} = \frac{10}{2\sqrt{x}} = \frac{5}{\sqrt{x}}$$

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

$$a = v \times \frac{5}{\sqrt{x}} = 10\sqrt{x} \times \frac{5}{\sqrt{x}} = 50\ ms^{-2}$$

$$F = ma = \frac{500}{1000} \times 50 = 25\ N$$

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

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

Sol. **(3)**

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mK}}$$

$$\frac{\lambda_P}{\lambda_e} = \sqrt{\frac{m_e}{m_p}} = \sqrt{\frac{m_e}{1840me}} = \frac{1}{\sqrt{1840}}$$

$$\frac{\lambda_P}{\lambda_e} = \frac{1}{43}$$ Ans. (3)

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

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

Sol. **(3)**

$\rho = F^x V^y T^z$

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

$1 = x$ $x = 1$

$-3 = x + y$ $y = -4$

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

$\rho = F V^{-4} T^{-2}$ Ans. (3)

40. 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 E only (4) B and C only

Sol. **(4)**

We know that

In the solenoid magnetic field along the axis of solenoid.

When charge particle moving inside solenoid along the axis F = 0

$\overrightarrow{F_m} = q\ (\vec{V} \times \vec{B})$

So, $\overrightarrow{F_m} = 0$

And it moves with constant velocity.

41. The Thermodynamic process, in which internal energy of the system remains constant is

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

Sol. **(4)**

$\Delta U = nC_V\Delta T$, for all process

For isothermal process, $\Delta T = 0$

So, $\Delta U = 0$

That means internal energy of system remains constant.

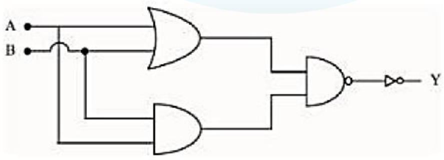
42. In satellite communication, the uplink frequency band used is:

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

Sol. **(4)**

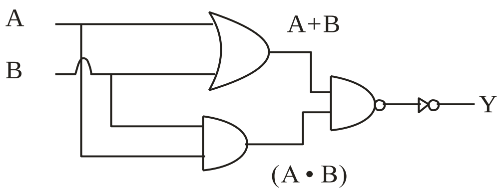
uplink	**Downlink**
5.8-6.2 Ghz	4-4.2 Ghz
I. standard	

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



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

Sol. **(4)**



$Y = \overline{\overline{(A+B).(AB)}}$

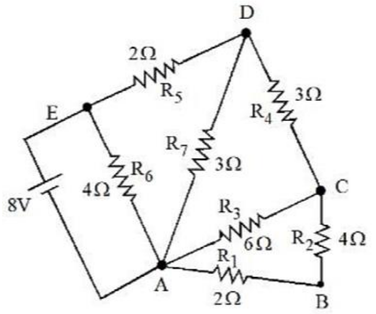
Y = (A + B).(AB)

Y = AB + AB

Y = (A.B)

Y = AND Gate

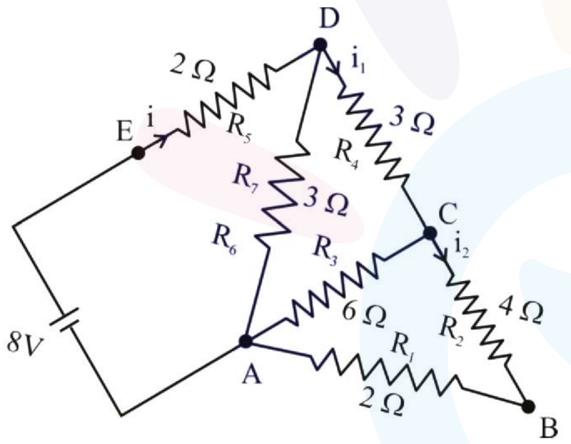
44.



The current flowing through R_2 is:

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

Sol. (1)



$R_{eq} = 4\Omega$

$i = \frac{8}{4} = 2A$

$i_1 = \frac{2\times3}{3+6} = \frac{2}{3}A$

$i_2 = \frac{2/3}{2} = \frac{1}{3}A$

45. 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) 3 (2) $\sqrt{5}$ (3) $\sqrt{13}$ (4) $\sqrt{6}$

Sol. (Bonus)

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

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

$\vec{B} = 2\hat{j} + \vec{A} = 2\hat{i} + 5\hat{j} + 2\hat{k}$

$|\vec{B}| = \sqrt{2^2 + 5^2 + 2^2} = \sqrt{4+25+4} = \sqrt{8+25} = \sqrt{33}$

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

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

Sol. (3)

$$V = -\frac{GM}{R^3}(1.5R^2 - 0.5r^2)$$

$$V = -\frac{GM}{R} \text{ [At the surface]}$$

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

47. 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) 523 m/s (4) 27.4 m/s

Sol. (3)

$$V_{rms} = \sqrt{\frac{3RT}{M_w}} = \sqrt{\frac{3RT}{mN_A}} = \sqrt{\frac{3KT}{m}}$$

$$= \sqrt{\frac{3 \times 1.4 \times 10^{-23} \times 300}{4.6 \times 10^{-26}}}$$

$$= \sqrt{\frac{9 \times 1.4 \times 10^{5}}{4.6}}$$

$$= \sqrt{2.73 \times 10^{5}}$$

$$= \sqrt{27.3 \times 10^{4}}$$

$= 522.4\ ms^{-1}$

$= 523\ ms^{-1}$

48. 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) –54.4 eV (3) –27.2 eV (4) –3.4 eV

Sol. (4)

$$E = -\left(\frac{13.6z^2}{n^2}\right) eV$$

First excited state

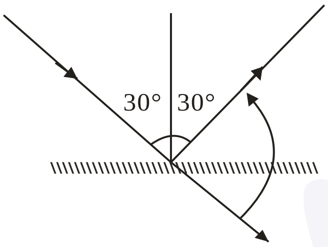
n = 2

$$E = \frac{-13.6 \times z^2}{2^2} = -13.6 \text{ eV}$$

49. 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) 130° (3) 120° (4) 110°

Sol. **(3)**



$\delta = \Pi - 2i = \Pi - 2 \times 30$

$= 180 - 60 = 120°$

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

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

Sol. **(2)**

$\phi = \frac{q}{\varepsilon_0}$

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

SECTION – B

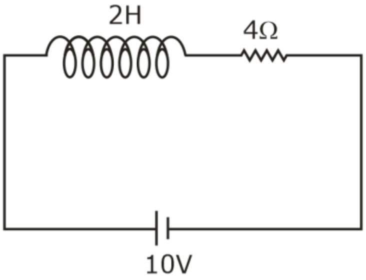
51. A coil has an inductance of 2H and resistance of 4 Ω. A 10 V is applied across the coil. The energy stored in the magnetic field after the current has built up to its equilibrium value will be __________ $\times 10^{-2}$ J.

Sol. **(625)**

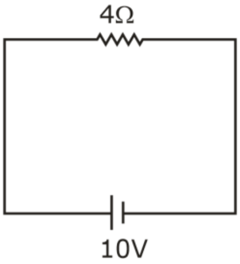
At steady state, inductor will act as a short circuit.

$I = \frac{V}{R} = \frac{10}{4} = \frac{5}{2}A$

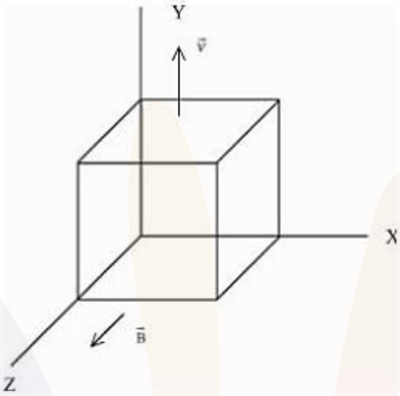
$E = \frac{1}{2}LI^2 = \frac{1}{2} \times 2 \times \left(\frac{5}{2}\right)^2 = \frac{25}{4} = 6.25 = 625 \times 10^{-2}$ J



⇒ at steady state



52. 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.



Sol. **(150)**

$qVB = qE$

$E = VB$

$\Delta V = EL = VBL$

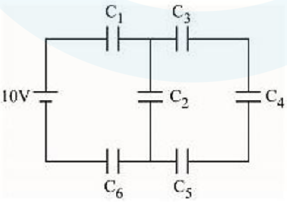
$\Delta V = 2 \times 0.5 \times \frac{15}{100} = \frac{15}{100}$ volt

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

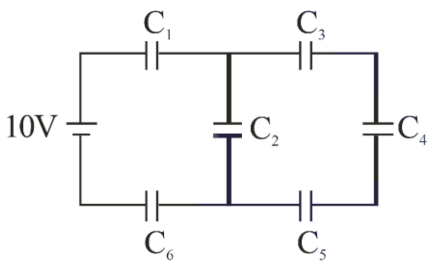
$= 150 \times 10^{-3}$ v

53. 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.



Sol. **(4)**



$C_{eq} = 0.5\ \mu F$

$Q = 0.5 \times 10 = 5\ \mu C$

$Q' = \frac{5\mu C \times 0.8}{0.8 + 0.2} = 4\mu C$

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

Sol. **(2)**

From LCM :

$m_1v_1 = m_2v_2$

$$\frac{V_1}{V_2} = \frac{m_2}{m_1} = \frac{r_2^{\,3}}{r_1^{\,3}} = \left(\frac{r_2}{r_1}\right)^3$$

$$\frac{V_1}{V_2} = \left(\frac{2^{\frac{1}{3}}}{1}\right)^3 = \frac{2}{1}$$

$\boxed{n = 2}$

55. 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 $\pi = 22/7$)

Sol. **(264)**

$W = \Delta U$

$W = 25 \times (A_f - A_i)$

$= 2 \times 5 \times 4\pi\ (r_f^{\,2} - r_i 2)$

$= 2 \times 3.5 \times 10^{-2} \times 4 \times \frac{22}{7} \times 10^{-4}$ (300)

$= 264 \times 10^{-4}$ J

56. A circular plate is rotating horizontal plane, about an axis passing through its center 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 $\frac{E}{x}$. The value of x is

Sol. **(3)**

$I_1\omega_1 = I_2\omega_2$

$I\omega = 3I\omega_2$

$\omega_2 = \frac{\omega}{3}$

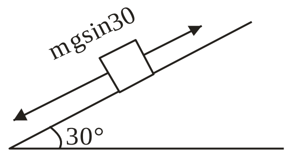
$E = \frac{1}{2} I\omega^2$

$$E_f = \frac{1}{2} \times 3I \times \left(\frac{\omega}{3}\right)^2 = \frac{\frac{1}{2}I\omega^2}{3}$$

x = 3

57. 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 starts is __________ W. [use g = 10 ms^{-2}] (Calculate the nearest integer value)

Sol. F – mg sin 30 = ma

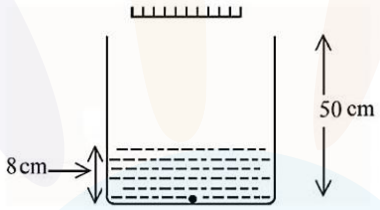


F = 5 × 1 + 25 = 30 N

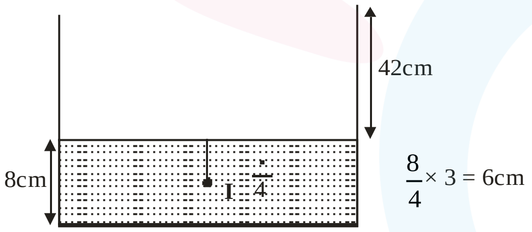
V = u + at = 0 + 1 × 10 = 10

P = FV = 30 × 10 = 300 watt

58. As shown in the figure, a plane mirror is fixed at a height of 50 cm from the bottom of tank containing water $\left(\mu = \frac{4}{3}\right)$. The height of water in 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.



Sol. **(98)**

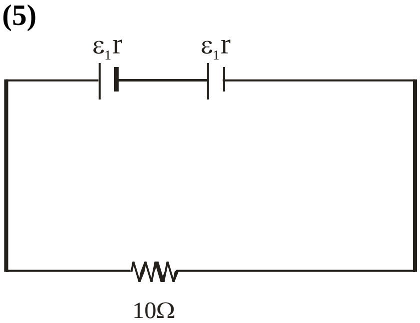


Apparent depth of O = $\frac{d}{\mu} = 6$

Distance between O and I_2 = 48 + 50 = 98 cm

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

Sol. **(5)**



$I = \frac{2\varepsilon}{10 + 2r} = \frac{1.5}{10}$

20ε = 15 + 3r

⇒ 20 × 1.5 = 15 + 3r

⇒ 30 = 15 + 3r

r = 5Ω

60. 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 $Y = 8 \times 10^{10}$ N/m^2, the fundamental frequency of vibration in the wire will be __________ Hz.

Sol. **(80)**

$$f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$$

$$f = \frac{1}{2\ell}\sqrt{\frac{YA\Delta\ell}{\ell\mu}}$$

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

$$f = \frac{1}{1}\sqrt{6400}$$

$f = 80$ Hz