FINAL JEE–MAIN EXAMINATION – APRIL, 2023
Held On Thursday 13th April, 2023
TIME : 03:00 PM to 06:00 PM

SECTION - A

31. Given below are two statements :
Statements I : An AC circuit undergoes electrical resonance if it contains either a capacitor or an inductor.
Statement II : An AC circuit containing a pure capacitor or a pure inductor consumes high power due to its non-zero power factor.
In the light of above statements, choose the correct answer form the options given below :
(1) Statement I is false but Statement II is true
(2) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are false
(4) Both Statement I and Statement II are true

Sol. **(3)**
Statement-I: An AC circuit for resonance inductor and capacitor both should required.
Statement-II: An AC circuit containing a pure capacitor and pure inductor have no power loss
For resonance, $\phi = 0$
means both capacitor and inductor must be present.

32. A passenger sitting in a train A moving at 90 km/h observes another train B moving in the opposite direction for 8 s. if the velocity of the train B is 54 km/h, then length of train B is :
(1) 120 m (2) 200 m (3) 320 m (4) 80 m

Sol. **(3)**

$$V_A = \frac{90\text{km}}{\text{hr}} = 25\text{ms}^{-1}$$

$$V_B = \frac{54\text{km}}{\text{hr}} = 15\text{ms}^{-1}$$

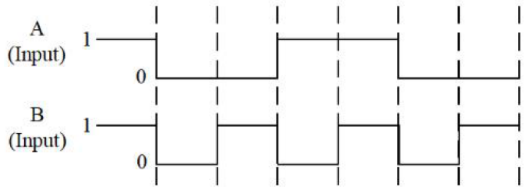
$$\overrightarrow{V_{BA}} = \overrightarrow{V_B} - \overrightarrow{VA} = 40\text{ms}^{-1}$$

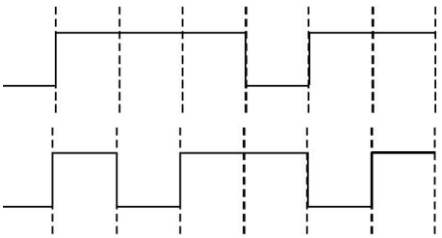
$$\text{Time of crossing} = \frac{\text{Length of train}}{\text{Relative velocity}}$$

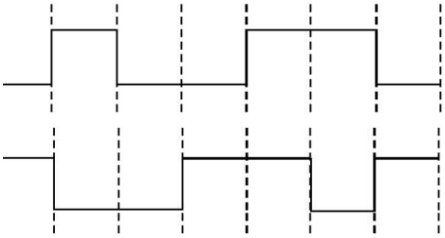
$$8 = \frac{\ell}{40}$$

$$\ell = 8 \times 40 = 320\,\text{meter}$$

33. The output from a NAND gate having inputs A and B given below will be,



(1) 

(2) 

(3)

(4)

Sol. **(1)**

Truth table for NAND gate is

A	B	$Y = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

On the basis of given input A and B the truth table is

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

34. The distance travelled by an object in time t is given by $s = (2.5)t^2$. The instantaneous speed of the object at t = 5 s will be :

(1) 25 ms^{-1} (2) 12.5 ms^{-1} (3) 5 ms^{-1} (4) 62.5 ms^{-1}

Sol. **(1)**

$$S = 2.5t^2$$

$$\text{Speed } (v) = \frac{ds}{dt} = 5t$$

$$\text{At, } t = 5\,\text{sec}.$$

$$v = 5 \times 5 = 25\,ms^{-1}$$

35. In a Young's double slits experiment, the ratio of amplitude of light coming from slits is 2 : 1. The ratio of the maximum to minimum intensity in the interference pattern is :

(1) 9 : 1 (2) 9 : 4 (3) 2 : 1 (4) 25 : 9

Sol. **(1)**

Given that

$$\frac{A_1}{A_2} = \frac{2}{1}$$

$$\frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} = \frac{9}{1}$$

$$= 9:1$$

36. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : The binding energy per nucleon is practically independent of the atomic number for nuclei of mass number in the range 30 to 170.
Reason R : Nuclear force is short ranged.
In the light of the above statements, choose the correct answer from the options given below
(1) Both A and R are true but R is NOT the correct explanation of A
(2) Both A and R are true and R is the correct explanation of A
(3) A is true but R is false
(4) A is false but R is true

Sol. **(2)**

37. Two planets A and B of radii R and 1.5 R have densities ρ and $\rho/2$ respectively. The ratio of acceleration due to gravity at the surface of B to A is :
(1) 2 : 3 (2) 2 : 1 (3) 4 : 3 (4) 3 : 4

Sol. **(4)**

$$g = \frac{GM}{R^2} = \frac{G \times \frac{4}{3}\pi R^3 \times \rho}{R^2} = \frac{4}{3}G\pi PR$$

$$\frac{g_2}{g_1} = \frac{R_2}{R_1} \times \frac{\rho_2}{\rho_1} = 1.5 \times \frac{1}{2} = \frac{3}{4}$$

38. The mean free path of molecules of a certain gas at STP is 1500d, where d is the diameter of the gas molecules. While maintaining the standard pressure, the mean free path of the molecules at 373 K is approximately :
(1) 750d (2) 1500d (3) 1098d (4) 2049d

Sol. **(4)**
mean free path λ

$$\lambda = \frac{RT}{\sqrt{2}\Pi d^2 N_A P}$$

$$\lambda \propto T$$

$$\frac{1500d}{\lambda} = \frac{273}{373}$$

$$\lambda = 2049d$$

39. To radiate EM signal of wavelength λ with high efficiency, the antennas should have a minimum size equal to:
(1) λ (2) $\frac{\lambda}{2}$ (3) 2λ (4) $\frac{\lambda}{4}$

Sol. **(4)**
Minimum length of antenna
Should be $\frac{\lambda}{4}$

40. A particle executes SHM of amplitude A. The distance from the mean position when its's kinetic energy becomes equal to its potential energy is :
(1) $\sqrt{2A}$ (2) $\frac{1}{2}A$ (3) $\frac{1}{\sqrt{2}}A$ (4) 2A

Sol. **(3)**
K.E = P.E

$$\frac{1}{2}M\omega^2(A^2 - x^2) = \frac{1}{2}M\omega^2 x^2$$

$$(A^2 - x^2) = x^2$$

$$2x^2 = A^2$$

$$x = \pm\frac{A}{\sqrt{2}}$$

41. In an electromagnetic wave, at an instant and at a particular position, the electric field is along the negative z axis and magnetic field is along the positive x-axis. Then the direction of propagation of electromagnetic wave is :

(1) negative y-axis (2) at 45^o angle from positive y-axis
(3) positive y-axis (4) positive z-axis

Sol. **(1)**

Direction of propagation of EM wave will be in the direction of $\left(\vec{E}\times\vec{B}\right)$

42. Given below are two statements :

Statement I : Out of microwaves, infrared rays and ultraviolet rays, ultraviolet rays are the most effective for the emission of electrons from a metallic surface.

Statement II : Above the threshold frequency, the maximum kinetic energy of photoelectrons is inversely proportional to the frequency of the incident light.

In the light of above statements, choose the correct answer form the options given below

(1) Statement I is false but statement II is true
(2) Both Statement I and Statement II are true
(3) Statement I is true but statement II is false
(4) Both Statement I and Statement II are false

Sol. **(3)**

UV rays have maximum frequency hence are most effective for emission of electrons from the metallic surface.

$KE_{max} = hf - hf_0$

43. Given below are two statements :

Statement I : For a planet, if the ratio of mass of the planet to its radius increases, the escape velocity from the planet also increases.

Statement II : Escape velocity is independent of the radius of the planet.

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

(1) Both Statement I and Statement II are correct
(2) Statement I is correct but statement II is incorrect
(3) Statement I is incorrect but statement II is correct
(4) Both Statement I and Statement II are incorrect

Sol. **(2)**

$V_e = \sqrt{\frac{2GM}{R}}$

As, $\frac{M}{R}$ increases $\Rightarrow V_e$ increases

$V_e \propto \frac{1}{\sqrt{R}}$

As, V_e depends on R

44. A vehicle of mass 200 kg is moving along a levelled curved road of radius 70 m with angular velocity of 0.2 rad/s. The centripetal force acting on the vehicle is:

(1) 2800 N (2) 560 N (3) 2240 N (4) 14 N

Sol. **(2)**

$F_c = m\omega^2 r = 200\times(0.2)^2\times 70$

$= 560N$

45. A 10 μC charge is divided into two parts and placed at 1 cm distance so that the repulsive force between them is maximum. The charges of the two parts are:

(1) 7 μC, 3 μC (2) 8 μC, 2 μC (3) 9 μC, 1 μC (4) 5 μC, 5 μC

Sol. **(4)**

Divide $q = 10\mu c$ into parts (x) and $(q-x)$

$$F = \frac{(K)(x)(q-x)}{r^2}$$

For F to be maximum

$$\frac{dF}{dx} = 0$$

$$x = \frac{q}{2} = \frac{10\mu C}{2} = 5\,\mu C$$

$q - x = 10\mu C - 5\mu C = 5\ \mu C$

46. In the equation $\left[x + \frac{a}{y^2}\right][Y - b] = RT$, X is pressure, Y is volume, R is universal gas constant ant T is temperature. The physical quantity equivalent to the ratio $\frac{a}{b}$ is :

(1) Coefficient of viscosity (2) Energy

(3) Impulse (4) Pressure gradient

Sol. **(2)**

x and $\frac{a}{y^2}$ have same dimensions

y and b have same dimensions

$$[a] = \left[ML^5T^{-2}\right]$$

$$[b] = \left[L^3\right]$$

$\frac{[a]}{[b]} = ML^2T^{-2}$ has dimension of energy

47. An electron is moving along the positive x-axis. If the uniform magnetic field is applied parallel to the negative z-axis, then

A. The electron will experience magnetic force along positive y-axis

B. The electron will experience magnetic force along negative y-axis

C. The electron will not experience any force in magnetic field

D. The electron will continue to move along the positive x-axis

E. The electron will move along circular path in magnetic field

Choose the correct answer from the options given below :

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

Sol. **(1)**

$$\vec{F} = q\left(\vec{V} \times \vec{B}\right)$$

$$\vec{F} = -e\left(\vec{V} \times \vec{B}\right)$$

Force will be along $-ve\ y\,axis$ As magnetic force is $\perp_r$ to velocity, path of electron must be circle.

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

Assertion A : A spherical body of radius (5 ± 0.1) mm having a particular density is falling through a liquid of constant density. The percentage error in the calculation of its terminal velocity is 4%

Reason R : The terminal velocity of the spherical body falling through the liquid is inversely proportional to its radius.

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

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

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

(3) A is false but R is true

(4) A is true but R is false

Sol. **(4)**

Terminal velocity of a spherical body in liquid

$V_t \propto r^2$

$\frac{\Delta V_t}{V_t} = 2\frac{\Delta r}{r}$

$\frac{\Delta V_t}{V_t} \times 100\% = 2 \times \frac{0.1}{5} \times 100 = 4\%$

Also, $V_t \propto r^2$

Reason (R) is false

49. The initial pressure and volume of an ideal gas are P_o and V_o. The final pressure of the gas when the gas is suddenly compressed to volume $\frac{V_o}{4}$ will be :

(Given γ = ratio of specific heats at constant pressure and at constant volume)

(1) $P_0(4)^{\frac{1}{\gamma}}$ (2) $4P_0$ (3) P_0 (4) $P_0(4)^{\gamma}$

Sol. **(4)**

As, gas in suddenly compressed, the process is adiabatic

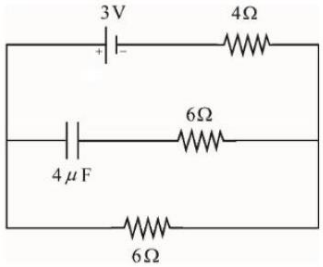
So equation of gas for adiabatic process is:

$PV^{\gamma} = \text{constant}$

$P_0V_0^{\gamma} = P_2\left(\frac{V_0}{4}\right)^{\gamma}$

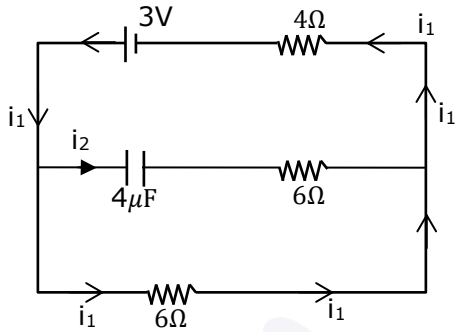
$P_2 = P_0(4)^{\gamma}$

50. In the network shown below, the charge accumulated in the capacitor in steady state will be :



(1) 4.8 μ C (2) 12 μ C (3) 7.2 μ C (4) 10.3 μ C

Sol. **(3)**



In steady state, no current will pass through capacitor hence capacitor will act as open circuit.

$i_2 = 0$

$i_1 = \frac{3}{6+4} = \frac{3}{10}A$

Potential difference on 6Ω resistor $= 6 \times \frac{3}{10} = 1.8$ volt capacitor will have same potential so charge

$= cv = 4 \times 1.8 = 7.2\mu c$

SECTION - B

51. In an experiment with sonometer when a mass of 180 g is attached to the string, it vibrates with fundamental frequency of 30 Hz. When a mass m is attached, the string vibrates with fundamental frequency of 50 Hz. The value of m is _____ g.

Sol. **(500)**

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

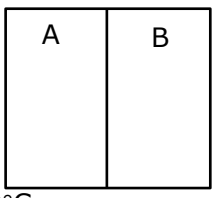
$\frac{f_2}{f_1} = \sqrt{\frac{T_2}{T_1}}$

$\left(\frac{50}{30}\right)^2 = \frac{mg}{180g}$

$m = \frac{25}{9} \times 180 = 500 gram$

52. Two plates A and B have thermal conductivities 84 $Wm^{-1} K^{-1}$ and 126 $Wm^{-1}K^{-1}$ respectively. They have same surface area and same thickness. They are placed in contact along their surfaces. If the temperatures of the outer surfaces of A and B are kept at 100 °C and 0 °C respectively, then the temperature of the surface of contact in steady state is _____ °C.

Sol. **(40)**



$T_A = 100°C$ T $T_B = 0°C$

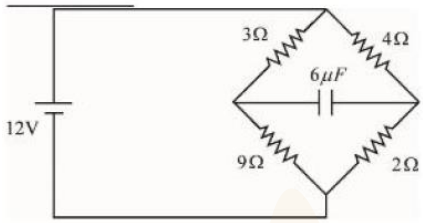
Let the temperature of contact surface is T then,

$\frac{K_A A(T_A - T)}{L} = \frac{K_B A(T - T_B)}{L}$

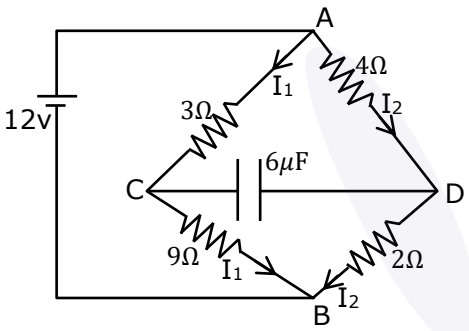
$84(100 - T) = 126(T - 0)$

$T = 40°C$

53. In the circuit shown, the energy stored in the capacitor is n μ J. The value of n is



Sol. **(75)**



$I_1 = \frac{12}{3+9} = 1A$

$I_2 = \frac{12}{4+2} = 2A$

$V_A - V_C = 3I_1 = 3V$

$V_A - V_D = 2 \times 4 = 8V$

So, $V_A - V_D = 5V$

$U = \frac{1}{2}CV^2 = \frac{1}{2} \times 6 \times 5^2 = 75\mu J$

54. A light rope is wound around a hollow cylinder of mass 5 kg and radius 70 cm. The rope is pulled with a force of 52.5 N. The angular acceleration of the cylinder will be _____ rad s^{-2}.

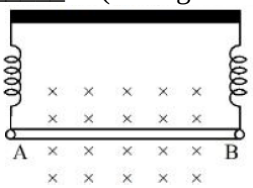
Sol. **(15)**

$\tau = I\alpha$

$FR = mR^2\alpha$

$\propto = \frac{F}{mR} = \frac{52.5}{5 \times 0.7} = 15 rads^{-2}$

55. A straight wire AB of mass 40 g and length 50 cm is suspended by a pair of flexible leads in uniform magnetic field of magnitude 0.40 T as shown in the figure. The magnitude of the current required in the wire to remove the tension in the supporting leads is _____A. (Take g = 10 ms^{-2})



Sol. **(2)**

For equilibrium :

$Mg = IlB$

$I = \frac{Mg}{lB} = \frac{40 \times 10^{-3} \times 10}{50 \times 10^{-2} \times 0.4} = 2A$

56. An insulated copper wire of 100 turns is wrapped around a wooden cylindrical core of the cross-sectional area 24 cm^2. The two ends of the wire are connected to a resistor. The total resistance in the circuit is 12 Ω. If an externally applied uniform magnetic field in the core along its axis changes from 1.5 T in one direction to 1.5 T in the opposite direction, the charge flowing through a point in the circuit during the change of magnetic field will be _____ mC.

Sol. **(60)**

$$|\Delta Q| = \frac{\Delta\phi}{R} = \frac{2NBA}{R}$$

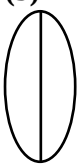
$$= \frac{2\times100\times1.5\times24\times10^{-4}}{12}$$

$$= 6\times10^{-2}\,c$$

$$= 60mc$$

57. A bi convex lens of focal length 10 cm is cut in two identical parts along a plane perpendicular to the principal axis. The power of each lens after cut is _____ D.

Sol. **(5)**

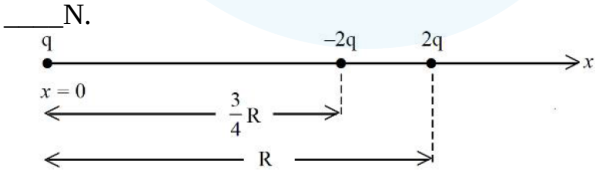


$$P_1 + P_1 = P = \frac{1}{f}$$

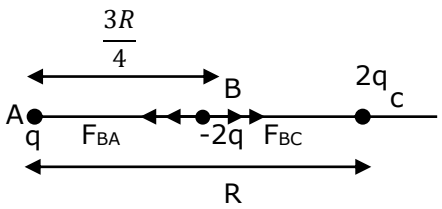
$$2P_1 = \frac{1}{0.1}$$

$$P_1 = 5D$$

58. Three point charges q, -2q and 2q are placed on x-axis at a distance x = 0, $x = \frac{3}{4}R$ and x = R respectively from origin as shown. If q = 2 × 10^{-6} C and R = 2 cm, the magnitude of net force experienced by the charge -2q is ____N.



Sol. **(5440)**



$$F_{BA} = \frac{32kq^2}{9q^2} \qquad F_{BC} = \frac{64kq^2}{R^2}$$

$$F_B = F_{BC} - F_{BA} = \frac{544kq^2}{9R^2}$$

$$= 5440N$$

59. An atom absorbs a photon of wavelength 500 nm and emits another photon of wavelength 600 nm. The net energy absorbed by the atom in this process is $n \times 10^{-4}$ eV. The value of n is _____.
[Assume the atom to be stationary during the absorption and emission process]
(Take $h = 6.6 \times 10^{-34}$ Js and $c = 3 \times 10^{8}$ m/s)

Sol. **(4125)**

$$E = E_1 - E_2 = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$$

$$E = 6.6 \times 10^{-20}\,J$$

$$E = 4.125 \times 10^{-1}\,eV$$

$$E = 4125 \times 10^{-4}\,eV$$

60. A car accelerates from rest to u m/s. The energy spent in this process is E J. The energy required to accelerate the car from u m/s to 2 u m/s is nE J. The value of n is _____.

Sol. **(3)**

$$E_1 = \frac{1}{2}mu^2 - 0 = \frac{1}{2}mu^2 = E$$

$$E_2 = \frac{1}{2}m(24)^2 - \frac{1}{2}mu^2$$

$$= \frac{3}{2}mu^2 = 3E$$