FINAL JEE–MAIN EXAMINATION – APRIL, 2024

(Held On Friday 05th April, 2024) **TIME : 3 : 00 PM to 6 : 00 PM**

SECTION-A

31. Given below are two statements :

Statement I : When the white light passed through a prism, the red light bends lesser than yellow and violet.

Statement II : The refractive indices are different for different wavelengths in dispersive medium. In the light of the above statements, choose the correct answer from the options given below :

(1) Both Statement I and Statement II are true.

(2) Statement I is true but Statement II is false.

(3) Both Statement I and Statement II are false.

(4) Statement I is false but Statement II is true.

Ans. **(1)**

Sol. As $\lambda_{red} > \lambda_{yellow} > \lambda_{violet}$

Light ray with longer wavelength bends less.

32. Which of the following statement is not true about stopping potential (V_0)?

(1) It depends on the nature of emitter material.

(2) It depends upon frequency of the incident light.

(3) It increases with increase in intensity of the incident light.

(4) It is 1/e times the maximum kinetic energy of electrons emitted.

Ans. **(3)**

Sol. $KE_{max} = h\nu - \phi_0 = eV$

33. The angular momentum of an electron in a hydrogen atom is proportional to : (Where r is the radius of orbit of electron)

(1) $\sqrt{r}$ (2) $\frac{1}{r}$

(3) r (4) $\frac{1}{\sqrt{r}}$

Ans. **(1)**

Sol. $F_C = \frac{mv^2}{r}$

$$\frac{Kq_1q_2}{r^2} = \frac{mv^2}{r}$$

$$mv^2r^2 = Kq_1q_2r$$

$$\frac{L^2}{m} = Kq_1q_2r$$

$$L \propto \sqrt{r}$$

34. A galvanometer of resistance 100 Ω when connected in series with 400 Ω measures a voltage of upto 10 V. The value of resistance required to convert the galvanometer into ammeter to read upto 10 A is $x \times 10^{-2}$ Ω. The value of x is :

(1) 2 (2) 800

(3) 20 (4) 200

Ans. **(3)**

Sol. $i_g = \frac{10}{400+100} = 20\times10^{-3}$ A

For ammeter

Let shunt resistance = S

$i_gR = (i - i_g)S$

$20 \times 10^{-3} \times 100 = 10$ S

$S = 20 \times 10^{-2}$ Ω

35. The vehicles carrying inflammable fluids usually have metallic chains touching the ground :

(1) To conduct excess charge due to air friction to ground and prevent sparking.

(2) To alert other vehicles.

(3) To protect tyres from catching dirt from ground.

(4) It is a custom.

Ans. **(1)**

Sol. Static charge is developed due to air friction. This can result in combustion. So, metallic chains is used to discharge excess charge.

36. If n is the number density and d is the diameter of the molecule, then the average distance covered by a molecule between two successive collisions (i.e. mean free path) is represented by :

(1) $\frac{1}{\sqrt{2n\pi d^2}}$ (2) $\sqrt{2}n\pi d^2$

(3) $\frac{1}{\sqrt{2}n\pi d^2}$ (4) $\frac{1}{\sqrt{2}n^2\pi^2 d^2}$

Ans. (3)

Sol. n = number of molecule per unit volume

d = diameter of the molecule

$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$ (By Theory)

37. A particle moves in x-y plane under the influence of a force $\vec{F}$ such that its linear momentum is $\vec{P}(t) = \hat{i}\cos(kt) - \hat{j}\sin(kt)$. If k is constant, the angle between $\vec{F}$ and $\vec{P}$ will be :

(1) $\frac{\pi}{2}$ (2) $\frac{\pi}{6}$

(3) $\frac{\pi}{4}$ (4) $\frac{\pi}{3}$

Ans. (1)

Sol. $\vec{P} = \cos(kt)\hat{i} - \sin(kt)\hat{j}$; $|\vec{P}| = 1$

$\because \vec{P} = m\vec{v}$

$\therefore \hat{P} = \hat{v}$

$\Rightarrow \hat{v} = \cos(kt)\hat{i} - \sin(kt)\hat{j}$

$\hat{a} = \frac{-k\sin(kt)\hat{i} - k\cos(kt)\hat{j}}{k}$

$\Rightarrow \hat{a} = -\sin kt\hat{i} - \cos kt\hat{j}$

$\hat{i} - \cos kt\,\hat{j}$

$\cos\theta = \frac{\hat{F}.\hat{P}}{|\hat{F}||\hat{P}|} = -\frac{\sin kt\cos t + \sin kt\cos t}{1\times 1} = 0$

$\Rightarrow \theta = \frac{\pi}{2}$

38. The electrostatic force $(\vec{F}_1)$ agnetic force $(\vec{F}_2)$ acting on a charge q moving with velocity v can be written :

(1) $\vec{F}_1 = q\vec{V}.\vec{E}$, $\vec{F}_2 = q(\vec{B}.\vec{V})$

(2) $\vec{F}_1 = q\vec{B}$, $\vec{F}_2 = q(\vec{B}\times\vec{V})$

(3) $\vec{F}_1 = q\vec{E}$, $\vec{F}_2 = q(\vec{V}\times\vec{B})$

(4) $\vec{F}_1 = q\vec{E}$, $\vec{F}_2 = q(\vec{B}\times\vec{V})$

Ans. (3)

Sol. $\vec{F}_1 = q\vec{E}$ (Theory)

$\vec{F}_2 = q(\vec{V}\times\vec{B})$

39. A man carrying a monkey on his shoulder does cycling smoothly on a circular track of radius 9m and completes 120 revolutions in 3 minutes. The magnitude of centripetal acceleration of monkey is (in m/s^2) :

(1) zero (2) 16 π^2 ms^{-2}

(3) $4\pi^2$ ms^{-2} (4) 57600 π^2 ms^{-2}

Ans. (2)

Sol. Given : R = 9m,

120 revolution in 3 min

$\omega = \frac{120\,\text{Rev.}}{3\,\text{min.}} = \frac{120\times 2\pi\text{ rad}}{3\times 60\text{ sec}} = \frac{4\pi}{3}\text{rad/s}$

$a_{centripetal} = \omega^2 R = \left(\frac{4\pi}{3}\right)^2 \times 9 = 16\pi^2\ \text{m/s}^2$

40. A series LCR circuit is subjected to an AC signal of 200 V, 50 Hz. If the voltage across the inductor (L = 10 mH) is 31.4 V, then the current in this circuit is ________ :

(1) 68 A (2) 63 A

(3) 10 A (4) 10 mA

Ans. (3)

Sol. Voltage across inductor $V_L = IX_L$

$31.4 = I[L\omega]$

$31.4 = I[L(2\pi f)]$

$31.4 = I[10 \times 10^{-3}(2 \times 3.14) \times 50$

$\Rightarrow I = 10$ A

41. What is the dimensional formula of ab^{-1} in the equation $\left(P+\frac{a}{V^2}\right)(V-b)=RT$, where letters have their usual meaning.

(1) $[M^0L^3T^{-2}]$ (2) $[ML^2T^{-2}]$

(3) $[M^{-1}L^5T^3]$ (4) $[M^6L^7T^4]$

Ans. (2)

Sol. $\because$ [V] = [b]

$\therefore$ Dimension of b = $[L^3]$

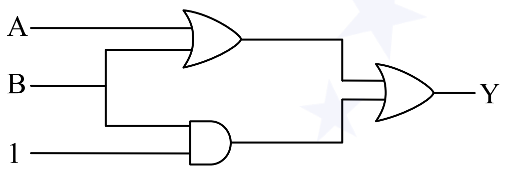
$\& \ [P]=\left[\frac{a}{V^2}\right]$

$[a] = [PV^2] = [ML^{-1}T^{-2}][L^6]$

Dimension of a = $[ML^5T^{-2}]$

$\therefore \ ab^{-1}=\frac{[ML^5T^{-2}]}{[L^3]}=[ML^2T^{-2}]$

42. The output (Y) of logic circuit given below is 0 only when :

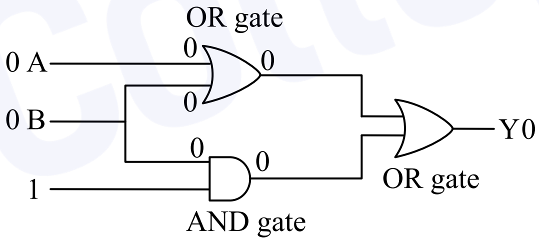


(1) A = 1, B = 0 (2) A = 0, B = 0

(3) A = 1, B = 1 (4) A = 0, B = 1

Ans. (2)

Sol.



43. A body is moving unidirectionally under the influence of a constant power source. Its displacement in time t is proportional to :

(1) t^2 (2) $t^{2/3}$

(3) $t^{3/2}$ (4) t

Ans. (3)

Sol. P = costant $\Rightarrow$ FV = constant

$\Rightarrow m\frac{dV}{dt}V$ = constant

$$\int_0^V VdV=(C)\int_0^t dt$$

$$\left(\frac{V^2}{2}\right)=Ct$$

$V \propto t^{1/2}$

$\frac{ds}{dt} \propto t^{1/2}$

$$\int_0^S ds=K\int_0^t t^{1/2}dt$$

$$S=K\times\frac{2}{3}t^{3/2}$$

$S \propto t^{3/2}$

$\therefore$ displacement is proportional to $(t)^{3/2}$

44. Match **List-I** with **List-II** :-

	List-I EM-Wave		List-II Wavelength Range
(A)	Infra-red	(I)	$< 10^{-3}$ nm
(B)	Ultraviolet	(II)	400 nm to 1 nm
(C)	X-rays	(III)	1 mm to 700 nm
(D)	Gamma rays	(IV)	1 nm to 10^{-3} nm

Choose the correct answer from the options given below :

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

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

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

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

Ans. (2)

Sol. Infrared is the least energetic thus having biggest wavelength (λ) & gamma rays are most energetic thus having smallest wavelength (λ).

45. During an adiabatic process, if the pressure of a gas is found to be proportional to the cube of its absolute temperature, then the ratio of $\frac{C_P}{C_V}$ for the gas is :

(1) $\frac{5}{3}$ (2) $\frac{9}{7}$

(3) $\frac{3}{2}$ (4) $\frac{7}{5}$

Ans. **(3)**

Sol. $P \propto T^3$

PT^{-3} = constant

$\because \frac{PV}{T} = nR$ = constant from ideal gas equation

$(P)\,(PV)^{-3}$ = constant

$P^{-2}\,V^{-3}$ = cosntant ...(1)

$\because$ Process equation for adiabatic process is

PV^{y} = constant ...(2)

Comparing equation (1) and (2)

$$\frac{C_P}{C_V} = y = \frac{3}{2}$$

46. Match **List-I** with **List-II** :

	List-I		**List-II**
(A)	A force that restores an elastic body of unit area to its original state	(I)	Bulk modulus
(B)	Two equal and opposite forces parallel to opposite faces	(II)	Young's modulus
(C)	Forces perpendicular everywhere to the surface per unit area same everywhere	(III)	Stress
(D)	Two equal and opposite forces perpendicular to opposite faces	(IV)	Shear modulus

Choose the correct answer from the options given below :

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

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

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

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

Ans. **(3)**

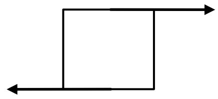
Sol. **(A)** stress $= \frac{F_{restoring}}{A}$

If A = 1

Stress = $F_{restoring}$

(A)-(III)

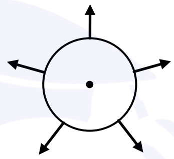
(B)



$\Rightarrow$ Shear stress

(B)-(IV)

(C)



$\Rightarrow$ Volumetric stress

(C)-(I)

(D)

$\Rightarrow$ Longitudinal stress

(D)-(II)

47. A vernier callipers has 20 divisions on the vernier scale, which coincides with 19th division on the main scale. The least count of the instrument is 0.1 mm. One main scale division is equal to ____mm.

(1) 1 (2) 0.5

(3) 2 (4) 5

Ans. **(3)**

Sol. 20 VSD = 19 MSD

$$1\text{VSD} = \frac{19}{20}\text{MSD}$$

L.C. = 1 MSD – 1 VSD

$$0.1\text{ mm} = 1\text{MSD} - \frac{19}{20}\text{MSD}$$

$$0.1 = \frac{1}{20}\text{MSD}$$

1 MSD = 2mm

48. A heavy box of mass 50 kg is moving on a horizontal surface. If co-efficient of kinetic friction between the box and horizontal surface is 0.3 then force of kinetic friction is :

(1) 14.7 N

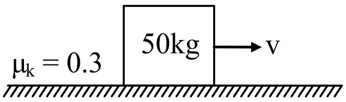
(2) 147 N

(3) 1.47 N

(4) 1470 N

Ans. **(2)**

Sol.



$F_k = \mu_k N = 0.3 \times 50 \times 9.8 = 147$ N

49. A satellite revolving around a planet in stationary orbit has time period 6 hours. The mass of planet is one-fourth the mass of earth. The radius orbit of planet is : (Given = Radius of geo-stationary orbit for earth is 4.2×10^4 km)

(1) 1.4×10^4 km

(2) 8.4×10^4 km

(3) 1.68×10^5 km

(4) 1.05×10^4 km

Ans. **(4)**

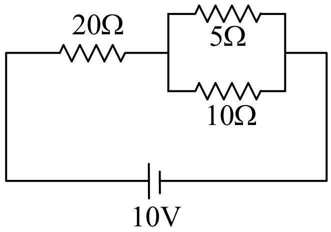
Sol. $T = \dfrac{2\pi r^{3/2}}{\sqrt{GM}}$

$$\frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2}\left(\frac{M_2}{M_1}\right)^{1/2}$$

$$\frac{6}{24} = \frac{(r_1)^{3/2}}{(4.2\times10^4)^{3/2}}\left(\frac{M}{M/4}\right)^{1/2}$$

$r_1 = 1.05 \times 10^4$ km

50. The ratio of heat dissipated per second through the resistance 5 Ω and 10 Ω in the circuit given below is :

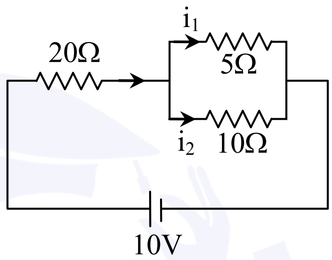


(1) 1 : 2 (2) 2 : 1

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

Ans. **(2)**

Sol.



$$\frac{i_1}{i_2} = \frac{10}{5} = \frac{2}{1}$$

$$\frac{P_1}{P_2} = \frac{i_1^2 R_1}{i_2^2 R_2} = \left(\frac{2}{1}\right)^2 \times \frac{5}{10} = \frac{2}{1}$$

SECTION-B

51. A solenoid of length 0.5 m has a radius of 1 cm and is made up of 'm' number of turns. It carries a current of 5A. If the magnitude of the magnetic field inside the solenoid is 6.28×10^{-3} T, then the value of m is :

Ans. **(500)**

Sol. $\mu_0 n i = B$ n = number of turns per unit length

$$\mu_0\left(\frac{m}{\ell}\right)i = B$$

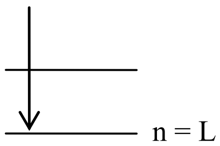
$$m = \frac{B.\ell}{\mu_0 i} = \frac{6.28\times10^{-3}\times0.5}{12.56\times10^{-7}\times5}$$

m = 500

52. The shortest wavelength of the spectral lines in the Lyman series of hydrogen spectrum is 915 Å. The longest wavelength of spectral lines in the Balmer series will be ________ Å.

Ans. (6588)

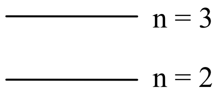
Sol. Lyman Series



Shortest, $\frac{hc}{\lambda} = -13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\lambda\downarrow\ E\uparrow\ ;\ \frac{hc}{\lambda_0} = -13.6(1)$

Balmer Series :



$\frac{hc}{\lambda_1} = -13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$\frac{hc}{\lambda_1} = -13.6\left(\frac{1}{4} - \frac{1}{9}\right)$

$\frac{hc}{\lambda_1} = -13.6\times\left(\frac{5}{36}\right)$

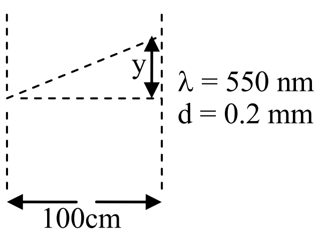
$3.6\times\frac{5}{36}$

$\frac{1}{\ } \frac{36}{\ } = \frac{915\times 36}{5} = 6588$

53. In a single slit experiment, a parallel beam of green light of wavelength 550 nm passes through a slit of width 0.20 mm. The transmitted light is collected on a screen 100 cm away. The distance of first order minima from the central maximum will be $x \times 10^{-5}$ m. The value of x is :

Ans. (275)

Sol.

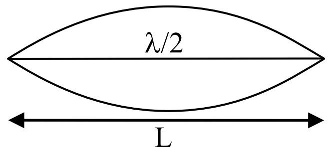


$y = \frac{\lambda D}{d} = \frac{550\times 10^{-9}\times 100\times 10^{-2}}{0.2\times 10^{-3}} = 275$

54. A sonometer wire of resonating length 90 cm has a fundamental frequency of 400 Hz when kept under some tension. The resonating length of the wire with fundamental frequency of 600 Hz under same tension ________ cm.

Ans. (60)

Sol.



$f_0 = 400\text{ Hz}\ ;\ \ v = \sqrt{\frac{T}{\mu}} = \text{constant}$

$\frac{\lambda}{2} = L\ ;\ \ v = f_0\lambda$

$\frac{v}{2f_0} = L \Rightarrow v = 2Lf_0$

$L' = \frac{v}{2f'} = \frac{2Lf_0}{2f'}$

$= \frac{Lf_0}{f'} = \frac{90\times 400}{600} = 60$

55. A hollow sphere is rolling on a plane surface about its axis of symmetry. The ratio of rotational kinetic energy to its total kinetic energy is $\frac{x}{5}$. The value of x is ________.

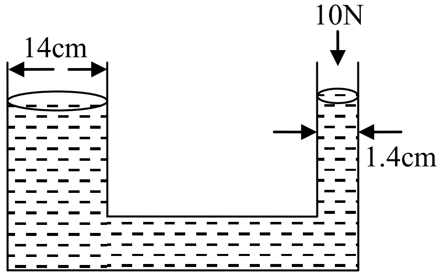
Ans. (2)

Sol. $\frac{\frac{1}{2}I\omega^2}{\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2} = \frac{\left(\frac{1}{2}\right)\left(\frac{2}{3}mR^2\right)\omega^2}{\left(\frac{1}{2}\right)\left(\frac{2}{3}mR^2\right)\omega^2 + \frac{1}{2}m(R\omega)^2}$

$= \frac{\frac{2}{3}}{\frac{2}{3}+1} = \frac{2}{5}$

$x = 2$

56. A hydraulic press containing water has two arms with diameters as mentioned in the figure. A force of 10 N is applied on the surface of water in the thinner arm. The force required to be applied on the surface of water in the thicker arm to maintain equilibrium of water is _______ N.



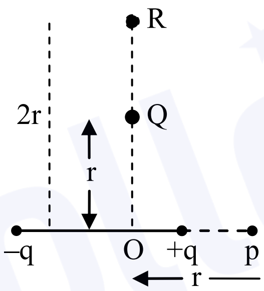
Ans. (1000 N)

Sol. $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

$\frac{F_1}{\pi(7)^2} = \frac{10}{\pi \times (0.7)^2}$

$F_1 = 1000$ N

57. The electric field at point p due to an electric dipole is E. The electric field at point R on equitorial line will be $\frac{E}{x}$. The value of x :



Ans. (16)

Sol. $E_P = \frac{2KP}{r^3} = E$

$E_R = \frac{KP}{(2r)^3} = \frac{E}{16}$

x = 16

58. The maximum height reached by a projectile is 64 m. If the initial velocity is halved, the new maximum height of the projectile is ______ m.

Ans. (16)

Sol. $H_{max} = \frac{u^2 \sin^2\theta}{2g}$

$\frac{H_{1max}}{H_{2max}} = \frac{u_1^2}{u_2^2}$

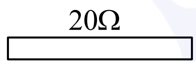
$\frac{64}{H_{2max}} = \frac{u^2}{(u/2)^2}$

$H_{2max} = 16$ m

59. A wire of resistance 20 Ω is divided into 10 equal parts. A combination of two parts are connected in parallel and so on. Now resulting pairs of parallel combination are connected in series. The equivalent resistance of final combination is _______ Ω.

Ans. (5)

Sol.



⇒ 10 equal part

Each part has resistance = 2Ω

2 parts are connected in parallel so, R = 1Ω

Now, there will be 5 parts each of resistance 1Ω, they are connected in series.

$R_{eq} = 5R$, $R_{eq} = 5\Omega$

60. The current in an inductor is given by I = (3t + 8) where t is in second. The magnitude of induced emf produced in the inductor is 12 mV. The self-inductance of the inductor _______ mH.

Ans. (4)

Sol. I = 3t + 8

$\varepsilon = 12$ mV

$|\varepsilon| = L\left|\frac{dI}{dt}\right|$

$12 = L \times 3$

L = 4 mH