JEE–MAIN EXAMINATION – APRIL 2025

(HELD ON THURSDAY 03rd APRIL 2025) **TIME : 3:00 PM TO 6:00 PM**

PHYSICS

TEST PAPER WITH SOLUTION

SECTION-A

26. A magnetic dipole experiences a torque of $80\sqrt{3}$ N m when placed in uniform magnetic field in such a way that dipole moment makes angle of 60° with magnetic field. The potential energy of the dipole is :

(1) 80 J (2) $-40\sqrt{3}$ J

(3) – 60 J (4) – 80 J

Ans. **(4)**

Sol. $\tau = M \times B = MB\sin 60 = \frac{\sqrt{3}}{2}MB = 80\sqrt{3}$

$MB = 160$

$U = -M.B = -MB\cos 60$

$U = -160 \times 1/2 = -80$ J

27. In the resonance experiment, two air columns (closed at one end) of 100 cm and 120 cm long, give 15 beats per second when each one is sounding in the respective fundamental modes. The velocity of sound in the air column is :

(1) 335 m/s (2) 370 m/s

(3) 340 m/s (4) 360 m/s

Ans. **(4)**

Sol. Fundamental frequency in close/organ pipe

$$(f) = \frac{v}{4\ell}$$

$$f_1 = \frac{v}{4\ell_1} \ \& \ f_2 = \frac{v}{4\ell_2}$$

$$\text{Beat} = (f_1 - f_2) = \frac{v}{4}\left(\frac{1}{\ell_1} - \frac{1}{\ell_2}\right)$$

$$15 = \frac{v}{4}\left(\frac{1}{1} - \frac{1}{1.2}\right)$$

$$v = \left(\frac{15 \times 4 \times 1.2}{0.2}\right) = 60 \times 6 = 360 \text{ m/s}$$

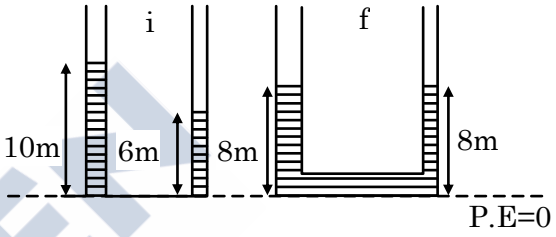
28. Two cylindrical vessels of equal cross sectional area of $2m^2$ contain water upto height 10m and 6m, respectively. If the vessels are connected at their bottom then the work done by the force of gravity is : (Density of water is 10^3 kg/m^3 and g = 10 m/s^2)

(1) 1×10^5 J (2) 4×10^4 J

(3) 6×10^4 J (4) 8×10^4 J

Ans. **(4)**

Sol.



$U_1 = (\rho A \times 10)g \times 5 + (\rho A 6)g \times 3$

$U_i = \rho Ag(50 + 18)$

$U_i = 68\rho Ag$

$U_f = (\rho A \times 16)g \times 4$

$= (\rho Ag) \times 64$

$\omega = \Delta U = 4 \times \rho Ag$

$= 4 \times 1000 \times 2 \times 10 = 8 \times 10^4$ J

29. Width of one of the two slits in a Young's double slit interference experiment is half of the other slit. The ratio of the maximum to the minimum intensity in the interference pattern is :

(1) $(2\sqrt{2}+1):(2\sqrt{2}-1)$ (2) $(3+2\sqrt{2}):(3-2\sqrt{2})$

(3) 9 : 1 (4) 3 : 1

Ans. **(2)**

Sol. $I \propto$ width $\quad I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

$\therefore I_1 = I_0, I_2 = 2I_0 \quad I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{2}+1\right)^2}{\left(\sqrt{2}-1\right)^2} \Rightarrow \frac{3+2\sqrt{2}}{3-2\sqrt{2}}$$

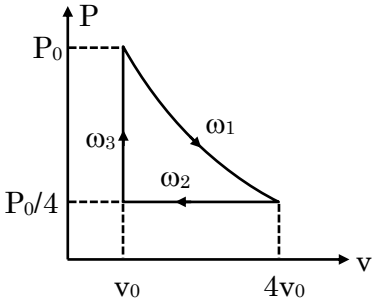
30. An ideal gas exists in a state with pressure P_0, volume V_0.It is isothermally expanded to 4 times of its initial volume (V_0), then isobarically compressed to its original volume. Finally the system is heated isochorically to bring it to its initial state. The amount of heat exchanged in this process is :

(1) $P_0V_0(2\ln 2 - 0.75)$ (2) $P_0V_0(\ln 2 - 0.75)$

(3) $P_0V_0(\ln 2 - 0.25)$ (4) $P_0V_0(2\ln 2 - 0.25)$

Ans. **(1)**

Sol.



$\omega_1 = P_0v_0\ell n4$

$$\omega_2 = \frac{P_0}{4}(-3v_0) = -\frac{3P_0v_0}{4}$$

$\omega_3 = 0$

$Q_T = \Delta U_{cyclic} + \omega$

$Q_T = \omega \qquad (\Delta U_{cyclic} = 0)$

$$Q_T = P_0v_0\left(\ell n4 - \frac{3}{4}\right)$$

$$= P_0v_0(2\ell n2 - 0.75)$$

31. Two monochromatic light beams have intensities in the ratio 1:9. An interference pattern is obtained by these beams. The ratio of the intensities of maximum to minimum is

(1) 8 : 1 (2) 9 : 1

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

Ans. **(4)**

Sol. $$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2} \Rightarrow \frac{(4)^2}{(2)^2} \Rightarrow \frac{16}{4} = 4$$

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

Assertion A : The Bohr model is applicable to hydrogen and hydrogen-like atoms only.

Reason R : The formulation of Bohr model does not include repulsive force between electrons.

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) **A** is false but **R** is true.

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

(4) **A** is true but **R** is false.

Ans. **(3)**

Sol. Conceptual

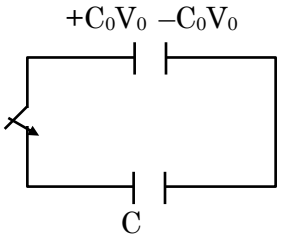
33. Using a battery, a 100 pF capacitor is charged to 60 V and then the battery is removed. After that, a second uncharged capacitor is connected to the first capacitor in parallel. If the final voltage across the second capacitor is 20 V, its capacitance is : (in pF)

(1) 600 (2) 200

(3) 400 (4) 100

Ans. **(2)**

Sol.



$$\text{New potential} = \frac{C_0V_0}{C_0 + C} = \frac{V_0}{3}$$

$3C_0V_0 = C_0V_0 + CV_0$

$2C_0V_0 = CV_0$

$C \Rightarrow 2C_0$

34. A monochromatic light of frequency 5×10^{14} Hz travelling through air, is incident on a medium of refractive index '2'. Wavelength of the refracted light will be :

(1) 300 nm (2) 600 nm

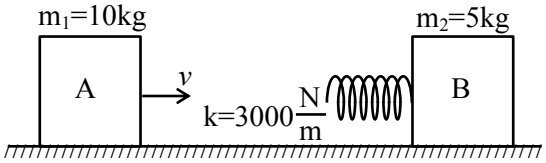
(3) 400 nm (4) 500 nm

Ans. **(1)**

Sol. $f\lambda = v \quad \lambda_{medium} = \frac{\lambda_{vacuum}}{\mu}$

$\lambda_{medium} \Rightarrow \frac{3\times10^8}{2\times5\times10^{14}} \Rightarrow 0.3 \times 10^{-6} \Rightarrow 300$ nm

35.



Consider two blocks A and B of masses $m_1 = 10$ kg and $m_2 = 5$ kg that are placed on a frictionless table. The block A moves with a constant speed $v = 3$ m/s towards the block B kept at rest. A spring with spring constant k = 3000 N/m is attached with the block B as shown in the figure. After the collision, suppose that the blocks A and B, along with the spring in constant compression state, move together, then the compression in the spring is, (Neglect the mass of the spring)

(1) 0.2 m (2) 0.4 m

(3) 0.1 m (4) 0.3 m

Ans. **(3)**

Sol. $m_1v_1 + m_2v_2 = (m_1 + m_2)v_{cm}$

$v_{cm} \Rightarrow \frac{10\times3}{10+5} \Rightarrow \frac{30}{15} = 2\text{m/s}$

$\frac{1}{2}kx^2 = \frac{1}{2}(10)(3)^2 - \left[\frac{1}{2}(15)(2)^2\right]$

$\Rightarrow 90 - 60 = 30 = 3000\,x^2$

$x^2 \Rightarrow \frac{30}{3000} = \frac{1}{100}$

$x \Rightarrow \frac{1}{10}\text{m}.$

36. A particle is projected with velocity u so that its horizontal range is three times the maximum height attained by it. The horizontal range of the projectile is given as $\frac{nu^2}{25g}$, where value of n is :

(Given 'g' is the acceleration due to gravity).

(1) 6 (2) 18

(3) 12 (4) 24

Ans. **(4)**

Sol. Range $= 3H_{max}$

$\frac{u^2\sin2\theta}{g} = \frac{3u^2\sin^2\theta}{2g}$

$2\sin\theta\cos\theta = \frac{3}{2}\sin^2\theta$

$\tan\theta = \frac{4}{3} \Rightarrow \theta = 53°$

$R = \frac{u^2\left(2\times\frac{3}{5}\times\frac{4}{5}\right)}{g} \Rightarrow \frac{24u^2}{25g}$

37. A solid steel ball of diameter 3.6 mm acquired terminal velocity 2.45×10^{-2} m/s while falling under gravity through an oil of density 925 kg m^{-3}. Take density of steel as 7825 kg m^{-3} and g as 9.8 m/s^2. The viscosity of the oil in SI unit is

(1) 2.18 (2) 2.38

(3) 1.68 (4) 1.99

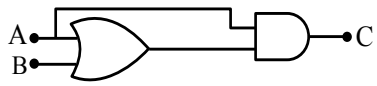
Ans. **(4)**

Sol. $v_T \Rightarrow \frac{2}{9}\frac{(\rho_0 - \rho_\ell)r^2g}{\eta}$

$\eta = \frac{2}{9}\left(\frac{7825-925}{2.45\times10^{-2}}\right)\times(1.8)^2\times10^{-6}\times9.8$

$\eta \approx 1.99$

38. The truth table corresponding to the circuit given below is



(1)

A	B	C
0	0	0
1	0	0
0	1	0
1	1	1

(2)

A	B	C
0	0	0
0	1	0
1	0	1
1	1	1

(3)

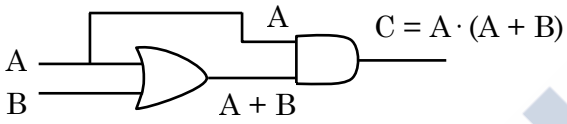
A	B	C
0	0	1
1	0	0
0	1	0
1	1	0

(4)

A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

Ans. **(2)**

Sol.



A	B	A + B	C
0	0	0	0
1	0	1	1
0	1	1	0
1	1	1	1

39. A particle moves along the x-axis and has its displacement x varying with time t according to the equation

$$x = c_0(t^2 - 2) + c(t - 2)^2$$

where c_0 and c are constants of appropriate dimensions. Then, which of the following statements is correct?

(1) the acceleration of the particle is $2c_0$

(2) the acceleration of the particle is 2c

(3) the initial velocity of the particle is 4c

(4) the acceleration of the particle is $2(c + c_0)$

Ans. **(4)**

Sol. $v = \frac{dx}{dt} = 2tC_0 + 2C(t-2)$

$$a = \frac{dv}{dt} = 2C_0 + 2C$$

40. An electric bulb rated as 100 W-220 V is connected to an ac source of rms voltage 220 V. The peak value of current through the bulb is :

(1) 0.64 A (2) 0.45 A

(3) 2.2 A (4) 0.32 A

Ans. **(1)**

Sol. $P = v_{rms} i_{rms}$

$$i_{rms} = \frac{100}{220}$$

$$i_0 = \sqrt{2} i_{rms} = 0.64A$$

41. Match the **LIST-I** with **LIST-II**

	LIST-I		**LIST-II**
A.	Boltzmann constant	I.	ML^2T^{-1}
B.	Coefficient of viscosity	II.	$MLT^{-3}K^{-1}$
C.	Planck's constant	III.	$ML^2T^{-2}K^{-1}$
D.	Thermal conductivity	IV.	$ML^{-1}T^{-1}$

Choose the ***correct*** answer from the options given below :

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

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

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

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

Ans. **(1)**

Sol. (A) $[k] = \frac{PV}{NT} = \frac{ML^2T^{-2}}{K} = ML^2T^{-2}K^{-1}$

(B) $[\eta] = \frac{F}{6\pi rv} = \frac{MLT^{-2}}{L^2T^{-1}} = ML^{-1}T^{-1}$

(C) $[h] = \frac{E}{f} = \frac{ML^2T^{-2}}{T^{-1}} = ML^2T^{-1}$

(D) $\frac{dQ}{dt} = k\frac{AdT}{dx}$

$$k = \frac{(ML^2T^{-3})L}{L^2.K} = MLT^{-3}K^{-1}$$

42. Pressure of an ideal gas, contained in a closed vessel, is increased by 0.4% when heated by 1°C. Its initial temperature must be :

(1) 25°C (2) 2500 K
(3) 250 K (4) 250°C

Ans. **(3)**

Sol. Isochoric process

$P \propto T$

$$\frac{\Delta P}{P} = \frac{\Delta T}{T}$$

$$\frac{0.4}{100} = \frac{1}{T}$$

$T = 250$ K

43. A motor operating on 100 V draws a current of 1 A. If the efficiency of the motor is 91.6%, then the loss of power in units of cal/s is

(1) 4 (2) 8.4
(3) 2 (4) 6.2

Ans. **(3)**

Sol. $P_{input} = Vi = 100$ W

$$\eta = \frac{P_{out}}{P_{input}} = 0.916$$

$P_{out} = 91.6$ W

Loss = 100 – 91.6 = 8.4 J/s = 2 cal/s

44. A block of mass 1 kg, moving along x with speed v_i = 10 m/s enters a rough region ranging from x = 0.1 m to x = 1.9 m. The retarding force acting on the block in this range is F_r = –kx N, with k = 10 N/m. Then the final speed of the block as it crosses rough region is

(1) 10 m/s (2) 4 m/s
(3) 6 m/s (4) 8 m/s

Ans. **(4)**

Sol. $$a = \frac{F}{m} = -10x$$

$$v\frac{dv}{dx} = -10x$$

$$\int_{10}^{v} vdv = -10\int_{0.1}^{1.9} xdx$$

$$\frac{v^2 - 100}{2} = -10\left(\frac{1.9^2 - 0.1}{2}\right)^2$$

$v = 8$ m/s

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

Assertion A : If oxygen ion (O^{-2}) and Hydrogen ion (H^+) enter normal to the magnetic field with equal momentum, then the path of O^{-2} ion has a smaller curvature than that of H^+.

Reason R : A proton with same linear momentum as an electron will form a path of smaller radius of curvature on entering a uniform magnetic field perpendicularly.

In the light of the above statement, 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**

Ans. **(1)**

Sol. $$r = \frac{mv}{qB} = \frac{p}{qB}$$

$$r \propto \frac{1}{q}$$

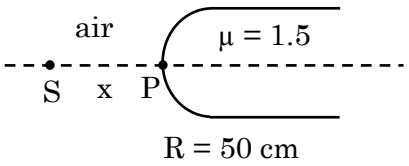
Assertion is true reason is false

SECTION-B

46. Light from a point source in air falls on a spherical glass surface (refractive index, μ = 1.5 and radius of curvature = 50 cm). The image is formed at a distance of 200 cm from the glass surface inside the glass. The magnitude of distance of the light source from the glass surface is _____m.

Ans. **(4)**

Sol.



$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1.5}{200} - \frac{1}{-x} = \frac{1.5-1}{50}$$

$$\frac{1}{x} = \frac{1}{100} - \frac{3}{400}$$

$x = 400$ cm

$x = 4$m

47. The excess pressure inside a soap bubble A in air is half the excess pressure inside another soap bubble B in air. If the volume of the bubble A is n times the volume of the bubble B, then, the value of n is _____.

Ans. **(8)**

Sol. $\Delta P = \frac{4T}{R}$

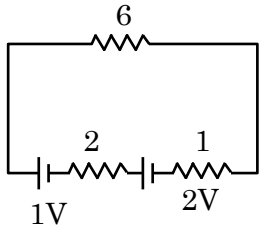
$$\frac{R_A}{R_B} = \frac{\Delta P_B}{\Delta P_A} = 2$$

$$\frac{V_A}{V_B} = \left(\frac{R_A}{R_B}\right)^3 = 8$$

48. Two cells of emf 1V and 2V and internal resistance 2 Ω and 1 Ω, respectively, are connected in series with an external resistance of 6 Ω. The total current in the circuit is I_1. Now the same two cells in parallel configuration are connected to same external resistance. In this case, the total current drawn is I_2. The value of $\left(\frac{I_1}{I_2}\right)$ is $\frac{x}{3}$. The value of x is _____.

Ans. **(4)**

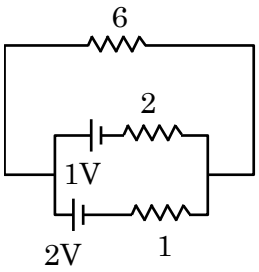
Sol.



$\varepsilon_{eq} = 3$

$R_{eq} = 9$

$i_1 = \frac{3}{9} = \frac{1}{3}$



$$\varepsilon_{eq} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}}$$

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

$$r_{equ} = \frac{2\times 1}{3} + 6 = \frac{20}{3}$$

$$i_2 = \frac{1}{4} \Rightarrow \frac{i_1}{i_2} = \frac{4}{3}$$

49. An electron in the hydrogen atom initially in the fourth excited state makes a transition to n^{th} energy state by emitting a photon of energy 2.86 eV. The integer value of n will be _____.

Ans. **(2)**

Sol. $E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_1^2}\right)$

$$2.86 = 13.6\left(\frac{1}{n^2} - \frac{1}{5^2}\right)$$

$$\frac{1}{n^2} = 0.21 + \frac{1}{2.5}$$

$n^2 = 4$

$n = 2$

Ans. **(2)**

50. A physical quantity C is related to four other quantities p, q, r and s as follows

$$C = \frac{pq^2}{r^3\sqrt{s}}$$

The percentage errors in the measurement of p, q, r and s are 1%, 2% 3% and 2% respectively.

The percentage error in the measurement of C will be _____%.

Ans. **(15)**

Sol. $C = P^1q^2r^{-3}s^{1/2}$

$$\left(\frac{dC}{C}\right)_{max} = \frac{dP}{P} + \frac{2dq}{q} + \frac{3dr}{r} + \frac{1}{2}\frac{ds}{s}$$

$$= (1 + 2\times 2 + 3\times 3 + \frac{1}{2}\times 2)\%$$

$= 15\ \%$

Ans. 15