JEE–MAIN EXAMINATION – APRIL 2025

(HELD ON MONDAY 07th APRIL 2025) **TIME : 3:00 PM TO 6:00 PM**

PHYSICS — TEST PAPER WITH SOLUTION

SECTION-A

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

Assertion (A) : The outer body of an air craft is made of metal which protects persons sitting inside from lightning-strikes.

Reason (R) : The electric field inside the cavity enclosed by a conductor is zero.

In the light of the above statements, chose the **most appropriate answer** from the options given below :

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

(2) **(A)** is correct but **(R)** is not correct

(3) Both **(A)** and **(R)** are correct but **(R)** is not correct explanation of **(A)**

(4) **(A)** is not correct but **(R)** is correct

Ans. (1)

Sol. Electric field of outside charge is zero inside conductor

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

Assertion (A) : The density of the copper $\left({}^{64}_{29}\text{Cu}\right)$ nucleus is greater than that of the carbon $\left({}^{12}_{6}\text{C}\right)$ nucleus.

Reason (R) : The nucleus of mass number A has a radius proportional to $A^{1/3}$.

In the light of the above statements, choose the **most appropriate answer** from the options given below :

(1) **(A)** is correct but **(R)** is not correct

(2) **(A)** is not correct but **(R)** is correct

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

(4) Both **(A)** and **(R)** are correct but **(R)** is not the correct explanation of **(A)**

Ans. (2)

Sol. $\rho = \frac{M}{V} = \frac{m_n \times A}{\frac{4}{3}\pi R^3} = \frac{m_n \times A}{\frac{4}{3}\pi A R_0^3}$

So ρ is almost is constant

$R = R_0 A^{1/3}$

$R \propto A^{1/3}$

28. The unit of $\sqrt{\frac{2I}{\epsilon_0 c}}$ is :

(I = intensity of an electromagnetic wave, c : speed of light)

(1) Vm (2) NC

(3) Nm (4) NC^{-1}

Ans. (4)

Sol. $I = \frac{1}{2}\epsilon_0 E_0^2 \times C$

$E_0 = \sqrt{\frac{2I}{\epsilon_0 C}}$

E_0 : electric field

N/C

29. The dimension of $\sqrt{\frac{\mu_0}{\epsilon_0}}$ is equal to that of :

(μ_0 = Vacuum permeability and ϵ_0 = Vacuum permittivity)

(1) Voltage

(2) Capacitance

(3) Inductance

(4) Resistance

Ans. (4)

Sol. $L = \dfrac{\mu_0 NA}{\ell}$

$C = \dfrac{A\in_0}{d}$

$\dfrac{L}{C} \propto \dfrac{\mu_0}{\in_0}$

$\sqrt{\dfrac{\mu_0}{\in_0}} \propto \sqrt{\dfrac{L}{C}}$

$\dfrac{L}{C} = \dfrac{\tau R}{(\tau/R)} = R^2$

$\sqrt{\dfrac{\mu_0}{\in_0}} = R$

30. A photo-emissive substance is illuminated with a radiation of wavelength λ_i so that it releases electrons with de-Broglie wavelength λ_e. The longest wavelength of radiation that can emit photoelectron is λ_0. Expression for de-Broglie wavelength is given by :

(m : mass of the electron, h : Planck's constant and c : speed of light)

(1) $\lambda_e = \sqrt{\dfrac{h}{2mc\left(\dfrac{1}{\lambda_i} - \dfrac{1}{\lambda_0}\right)}}$

(2) $\lambda_e = \sqrt{\dfrac{h\lambda_0}{2mc}}$

(3) $\lambda_e = \dfrac{h}{\sqrt{2mc\left(\dfrac{1}{\lambda_i} - \dfrac{1}{\lambda_0}\right)}}$

(4) $\lambda_e = \sqrt{\dfrac{h\lambda_i}{2mc}}$

Ans. **(1)**

Sol. K.E = E – W

$\lambda_e = \dfrac{h}{\sqrt{2mK.E}}, E = \dfrac{hc}{\lambda_i}, W = \dfrac{hc}{\lambda_0}$

$\dfrac{h^2}{2m\lambda_e^2} = \dfrac{hc}{\lambda_i} - \dfrac{hc}{\lambda_0}$

$\lambda_e = \sqrt{\dfrac{h}{2mc\left(\dfrac{1}{\lambda_i} - \dfrac{1}{\lambda_0}\right)}}$

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

Assertion (A) : The radius vector from the Sun to a planet sweeps out equal areas in equal intervals of time and thus areal velocity of planet is constant.

Reason (R) : For a central force field the angular momentum is a constant.

In the light of the above statements, choose the **most appropriate answer** from the options given below :

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

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

(3) **(A)** is correct but **(R)** is not correct

(4) (A) is not correct but (R) is correct

Ans. **(1)**

Sol. $\dfrac{dA}{dt} = \dfrac{L}{2m}$

Due to central force torque is zero & angular momentum is constant.

32. The helium and argon are put in the flask at the same room temperature (300 K). The ratio of average kinetic energies (per molecule) of helium and argon is :

(Give : Molar mass of helium = 4 g/mol, Molar mass of argon = 40 g/ mol)

(1) 1 : 10 (2) 10 : 1

(3) 1 : $\sqrt{10}$ (4) 1 : 1

Ans. **(4)**

Sol. $K.E = \frac{f}{2}KT$

For He and Ar $f = 3$

$$\frac{K.E_{He}}{K.E_{Ar}} = \frac{1}{1}$$

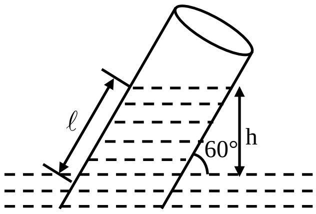
33. A capillary tube of radius 0.1 mm is partly dipped in water (surface tension 70 dyn/cm and glass water contact angle $\simeq 0°$) with $30°$ inclined with vertical. The length of water risen in the capillary is ______cm.

(Take $g = 9.8\ m/s^2$)

(1) $\frac{82}{5}$ (2) $\frac{57}{2}$ (3) $\frac{71}{5}$ (4) $\frac{68}{5}$

Ans. **(1)**

Sol.



$$h = \frac{2T\cos\theta}{\rho g r} = \frac{2\times70\times1}{1\times980\times10^{-2}}$$

$$h = \frac{100}{7}cm$$

$$\sin 60° = \frac{h}{\ell}$$

$$\ell = \frac{h\times2}{\sqrt{3}}$$

$$\ell = \frac{100}{7}\times\frac{2}{\sqrt{3}}$$

$$= \frac{200}{7\times\sqrt{3}}$$

$= 16.49$ cm

34. A mirror is used to produce an image with magnification of $\frac{1}{4}$. If the distance between object and its image is 40 cm, then the focal length of the mirror is _____.

(1) 10 cm (2) 12.7 cm
(3) 10.7 cm (4) 15 cm

Ans. **(3)**

Sol. $m = -\frac{v}{u} = -\left(\frac{v}{-u}\right) = \frac{v}{u}$

$\frac{1}{4} = \frac{v}{u} \Rightarrow u = 4v$

$v + u = 40$

$5v = 40$

$v = 8$ cm

$u = 32$ cm

$\frac{1}{v} + \frac{v}{u} = \frac{1}{f}$

$\frac{1}{8} - \frac{1}{32} = \frac{1}{f}$

$\frac{4-1}{32} = \frac{1}{f}$

$f = \frac{32}{3} = 10.7cm$

35. A dipole with two electric charges of 2 μC magnitude each, with separation distance 0.5 μm, is placed between the plates of a capacitor such that its axis is parallel to an electric field established between the plates when a potential difference of 5 V is applied. Separation between the plates is 0.5 mm. If the dipole is rotated by 30° from the axis, it tends to realign in the direction due to a torque. The value of torque is :

(1) 5×10^{-9} Nm (2) 5×10^{-3} Nm
(2) 2.5×10^{-12} Nm (4) 2.5×10^{-9} Nm

Ans. **(1)**

Sol. $E = \frac{v}{d} = \frac{5}{5\times10^{-4}} = 10^4 V/m$

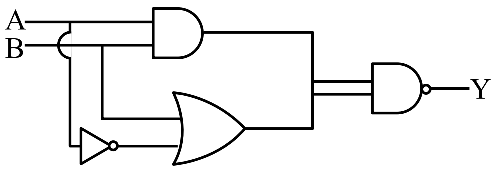
$\tau = PE\sin\theta$

Where $P = qa = 2 \times 10^{-6} \times 5 \times 10^{-7}$

$= 1 \times 10^{-12}$C-m

$\tau = 1 \times 10^{-12} \times 10^4 \times \frac{1}{2} = 5 \times 10^{-9}$ N-m

36. Consider the following logic circuit.



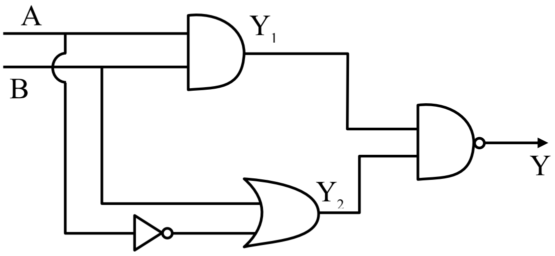
The output is Y = 0 when :

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

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

Ans. (1)

Sol.



$Y_1 = A \cdot B, Y_2 = \overline{A} + B$

$Y = \overline{Y_1 \cdot Y_2} = \overline{Y_1} + \overline{Y_2}$

$Y = \overline{A \cdot B} + \overline{\overline{A} + B}$

$Y = \overline{A} + \overline{B} + A \cdot \overline{B}$

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

37. Match **List-I** with **List-II**.

List-I		List-II	
(A)	Mass density	(I)	$[ML^2T^{-3}]$
(B)	Impulse	(II)	$[MLT^{-1}]$
(C)	Power	(III)	$[ML^2T^0]$
(D)	Moment of inertia	(IV)	$[ML^{-3}T^0]$

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

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

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

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

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

Ans. (3)

Sol. (A) Mass density = $\frac{M}{V} = M^1L^{-3}$ … (iv)

(B) Impulse = M × u = $M^1L^1T^{-1}$ … (ii)

(C) Power = F.V = $M^1L^2T^{-3}$ … (i)

(D) Moment of inertia = $Mr^2 = M^1L^2$ … (iii)

38. The equation of a wave travelling on a string is $y = \sin[20\pi x + 10\pi t]$, where x and t are distance and time in SI units. The minimum distance between two points having the same oscillating speed is :

(1) 5.0 cm (2) 20 cm

(3) 10 cm (4) 2.5 cm

Ans. (1)

Sol. Minimum distance between 2 points having same speed is $\frac{\lambda}{2}$.

$\lambda = \frac{2\pi}{k} = \frac{1}{10} m = 10cm$

Distance = $\frac{\lambda}{2} = 5cm$

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

Assertion (A) : Refractive index of glass is higher than that of air.

Reason (R) : Optical density of a medium is directly proportionate to its mass density which results in a proportionate refractive index.

In the light of the above statements, choose the **most appropriate answer** from the options given below :

(1) **(A)** is not correct but **(R)** is correct

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

(3) **(A)** is correct but **(R)** is not correct

(4) Both **(A)** and **(R)** are correct but **(R)** is **not** the correct explanation of **(A)**

Ans. (3)

Sol. Refractive index has no relation with mass density because both have different meaning. Hence reason is incorrect.

So (A) is correct but (R) is not correct.

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

Assertion (A) : Magnetic monopoles do not exist.

Reason (R) : Magnetic field lines are continuous and form closed loops.

In the light of the above statements, choose the **most appropriate answer** from the options given below :

(1) Both **(A)** and **(R)** are correct but **(R)** is **not** the correct explanation of **(A)**

(2) **(A)** is correct but **(R)** is not correct

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

(4) **(A)** is not correct but **(R)** is correct

Ans. (3)

Sol. Both statements are correct and reason is also the correct explanation of assertion.

41. Which one of the following forces cannot be expressed in terms of potential energy?

(1) Coulomb's force (2) Gravitational force

(3) Frictional force (4) Restoring force

Ans. (3)

Sol. Potential energy is defined for conservative force only. It is not defined for non-conservative force i.e. frictional force.

42. Match **List-I** with **List-II.**

List-I		List-II	
(A)	Isothermal	(I)	ΔW (work done) = 0
(B)	Adiabatic	(II)	ΔQ (supplied heat) = 0
(C)	Isobaric	(III)	ΔU (change in internal energy) $\neq 0$
(D)	Isochoric	(IV)	$\Delta U = 0$

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

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

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

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

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

Ans. (3)

Sol. (A) Isothermal $\rightarrow \Delta T = 0 \rightarrow \Delta U = 0$ (IV)

(B) Adiabatic $\rightarrow \Delta Q = 0$ (II)

(C) Isobaric $\rightarrow \Delta P = 0 \rightarrow \Delta U \neq 0$ (III)

(D) Isochoric $\rightarrow \Delta V = 0 \rightarrow \Delta W = 0$ (I)

43. A helicopter flying horizontally with a speed of 360 km/h at an altitude of 2 km, drops an object at an instant. The object hits the ground at a point O, 20 s after it is dropped. Displacement of 'O' from the position of helicopter where the object was released is :

(use acceleration due to gravity g = 10 m/s^2 and neglect air resistance)

(1) $2\sqrt{5}$ km

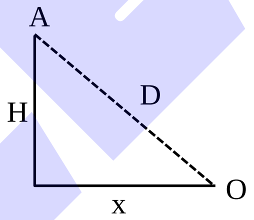
(2) 4 km

(3) 7.2 km

(4) $2\sqrt{2}$ km

Ans. (4)

Sol.



$$u = 360 \times \frac{5}{18} = 100 \text{m/s}$$

$$x = u \times t = 2 \times 10^3 \text{m}$$

$$t = \sqrt{\frac{2H}{g}} \Rightarrow H = \frac{t^2 g}{2}$$

$$H = \frac{400 \times 10}{2}$$

H = 2000 m

$$D = \sqrt{x^2 + H^2}$$

$$D = 2\sqrt{2}\text{km}$$

44. An object with mass 500 g moves along x-axis with speed $v = 4\sqrt{x}$ m/s. The force acting on the object is :

(1) 8 N (2) 5 N

(3) 6 N (4) 4 N

Ans. (4)

Sol. $F = M \times a$

$v = 4\sqrt{x}$

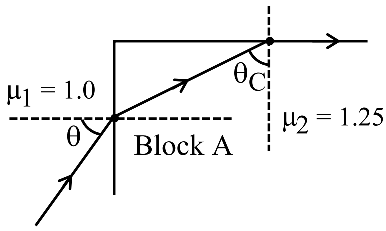
$v^2 = 16x$

$2v\dfrac{dv}{dx} = 16$

$\dfrac{vdv}{dx} = \dfrac{16}{2} = 8$

$F = 0.5 \times 8 = 4$ N

45. A transparent block A having refractive index $\mu = 1.25$ is surrounded by another medium of refractive index $\mu = 1.0$ as shown in figure. A light ray is incident on the flat face of the block with incident angle θ as shown in figure. What is the maximum value of θ for which light suffers total internal reflection at the top surface of the block ?

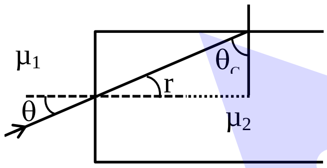


(1) $\tan^{-1}(4/3)$ (2) $\tan^{-1}(3/4)$

(3) $\sin^{-1}(3/4)$ (4) $\cos^{-1}(3/4)$

Ans. **(3)**

Sol.



$r + \theta_C = 90°$

$\mu_1 \sin\theta = \mu_2 \sin r$

$\sin\theta = \dfrac{\mu_2}{\mu_1}\sin(90 - \theta_C)$

$\sin\theta = \dfrac{\mu_2}{\mu_1}\cos\theta_C$

$\sin\theta_C = \dfrac{\mu_1}{\mu_2}$

$\sin\theta = \dfrac{\mu_2}{\mu_1}\sqrt{1 - \dfrac{\mu_1^2}{\mu_2^2}}$

$\sin\theta = \sqrt{\dfrac{\mu_2^2 - \mu_1^2}{\mu_1^2}} = \sqrt{\dfrac{\frac{25}{16} - 1}{1}}$

$\sin\theta = \dfrac{3}{4}$

$\theta = \sin^{-1}\left(\dfrac{3}{4}\right)$

SECTION-B

46. A parallel plate capacitor has charge 5×10^{-6} C. A dielectric slab is inserted between the plates and almost fills the space between the plates. If the induced charge on one face of the slab is 4×10^{-6} C then the dielectric constant of the slab is ________.

Ans. **(5)**

Sol. $Q_{in} = Q\left(1 - \dfrac{1}{K}\right)$

$4 \times 10^{-6} = 5 \times 10^{-6}\left(1 - \dfrac{1}{K}\right)$

$1 - \dfrac{1}{K} = \dfrac{4}{5}$

$K = 5$

47. An inductor of reactance 100 Ω, a capacitor of reactance 50 Ω, and a resistor of resistance 50 Ω are connected in series with an AC source of 10 V, 50 Hz. Average power dissipated by the circuit is ________ W.

Ans. **(1)**

Sol. $P = V_{rms} I_{rms} \cos\phi$

$P = V_{rms} \times \dfrac{V_{rms}}{z} \times \dfrac{R}{z}$

$P = V_{rms}^2 \times \dfrac{R}{z^2}$

$z = \sqrt{R^2 + (x_L - x_C)^2}$

$z = 50\sqrt{2}\,\Omega$

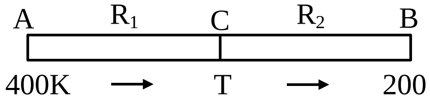
$P = 100 \times \dfrac{50}{2500 \times 2} = 1\text{W}$

48. Two cylindrical rods A and B made of different materials, are joined in a straight line. The ratio of lengths, radii and thermal conductivities of these rods are :

$\frac{L_A}{L_B}=\frac{1}{2}, \frac{r_A}{r_B}=2$ and $\frac{K_A}{K_B}=\frac{1}{2}$. The free ends of rods A and B are maintained at 400 K, 200 K, respectively. The temperature of rods interface is ______________ K, when equilibrium is established.

Ans. **(360)**

Sol.



$$R_1=\frac{\ell_1}{K_1A_1}, R_2=\frac{\ell_2}{K_2A_2}$$

$$\frac{dQ}{dt}=\frac{\Delta T}{R}$$

$$\left(\frac{dQ}{dt}\right)_1=\left(\frac{dQ}{\mu}\right)_2$$

$$\frac{400-T}{R_1}=\frac{T-200}{R_2}$$

$$\frac{400-T}{T-200}=\frac{R_1}{R_2}=\left(\frac{\ell_1}{\ell_2}\right)\left(\frac{r_2}{r_1}\right)^2\times\frac{K_2}{K_1}$$

$$=\frac{1}{2}\times\left(\frac{1}{2}\right)^2\times 2$$

$$=\left(\frac{1}{4}\right)$$

$$\frac{400-T}{T-200}=\frac{1}{4}$$

$$1600-4T=T-200$$

$$5T=1800$$

$$T=360 \text{ K}$$

49. The electric field in a region is given by $\vec{E}=\left(2\hat{i}+4\hat{j}+6\hat{k}\right)\times10^3 \text{ N/C}$. The flux of the field through a rectangular surface parallel to x-z plane is $6.0 \text{ Nm}^2\text{C}^{-1}$. The area of the surface is _____ cm^2.

Ans. **(15)**

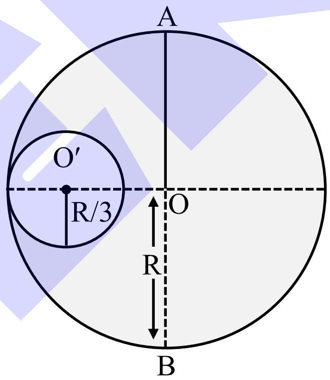
Sol. $\phi=\vec{E}\cdot\vec{A}=\left(2\hat{i}+4\hat{j}+6\hat{k}\right)\times10^3\cdot A\hat{j}$

$$6=4\times10^3 A$$

$$A=1.5\times10^{-3} \text{ m}^2$$

$$=15 \text{ cm}^2$$

50. M and R be the mass and radius of a disc. A small disc of radius R/3 is removed from the bigger disc as shown in figure. The moment of inertia of remaining part of bigger disc about an axis AB passing through the centre O and perpendicular to the plane of disc is $\frac{4}{x}MR^2$. The value of x is ________.



Ans. **(9)**

Sol. Without cavity $I_1=\frac{MR^2}{2}$

Mass of removed disc $=\frac{M}{\pi R^2}\times\left(\frac{R}{3}\right)^2\pi$

$$=\left(\frac{M}{9}\right)$$

M.I. of removed disc $I_2=\frac{\frac{M}{9}\left(\frac{R}{3}\right)^2}{2}+\frac{M}{9}\times\left(\frac{2R}{3}\right)^2$

$$=\frac{MR^2}{18}$$

$$I=I_1-I_2=\frac{MR^2}{2}-\frac{MR^2}{18}=\frac{4MR^2}{9}$$

(n = 9)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