# JEE Main Physics Sample Paper-17

**Duration: 1 Hour** **Maximum Marks: 100**

## Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

## Section A — Multiple Choice Questions

**Q1.** The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately: [JEE Main 2021]

(A) 310 nm

(B) 400 nm

(C) 540 nm

(D) 220 nm

**Q2.** An electron is accelerated through a potential difference of 10,000 V. Its de Broglie wavelength is, nearly: [JEE Main 2022]

(A) $12.2 \times 10^{-12}$ m

(B) $12.2 \times 10^{-14}$ m

(C) 12.2 nm

(D) $12.2 \times 10^{-10}$ m

**Q3.** A hydrogen atom in its ground state absorbs 10.2 eV of energy. The angular momentum of the electron is increased by: [JEE Main 2020]

(A) $1.05 \times 10^{-34}$ J · s

(B) $2.11 \times 10^{-34}\,\text{J} \cdot \text{s}$

(C) $3.16 \times 10^{-34}\,\text{J} \cdot \text{s}$

(D) $4.22 \times 10^{-34}\,\text{J} \cdot \text{s}$

**Q4.** The half-life of a radioactive substance is 20 minutes. The time taken between 20% decay and 80% decay is: [JEE Main 2023]

(A) 20 min

(B) 40 min

(C) 30 min

(D) 25 min

**Q5.** A point charge $q$ is placed at a distance $d$ from an infinite grounded conducting plane. The image charge is: [JEE Main 2019]

(A) $-q$ at distance $d$

(B) $+q$ at distance $d$

(C) $-q$ at distance $2d$

(D) $q/2$ at distance $d$

**Q6.** A parallel plate capacitor with air between the plates has a capacitance of 9 pF. The separation between the plates is $d$. A dielectric slab of thickness $d/3$ and dielectric constant $K = 3$ is introduced. The new capacitance is: [JEE Main 2024]

(A) 12.15 pF

(B) 13.5 pF

(C) 18 pF

(D) 4.5 pF

**Q7.** An electric dipole is placed at an angle of 30° with an electric field of intensity $2 \times 10^5\,\text{N/C}$. It experiences a torque equal to $4\,\text{N} \cdot \text{m}$. If the dipole length is 2 cm, the charge on the dipole is: [JEE Main 2021]

(A) 2 mC

(B) 5 mC

(C) 7 $\mu C$

(D) 1 mC

**Q8.** In the circuit shown, the internal resistance of the 18 V cell is negligible. If $R_1 = 400\,\Omega$, $R_2 = 800\,\Omega$ and the reading of the voltmeter is 5 V, the resistance of the voltmeter is: [JEE Main 2020]

(A) $1200\,\Omega$

(B) $1100\,\Omega$

(C) $1333\,\Omega$

(D) $400\,\Omega$

**Q9.** A potentiometer wire of length 10 m has a resistance of $20\,\Omega$. It is connected in series with a battery of 3 V and a resistance of $10\,\Omega$. The potential gradient of the wire is: [JEE Main 2022]

(A) 0.2 V/m

(B) 0.1 V/m

(C) 0.3 V/m

(D) 1.2 V/m

**Q10.** Two resistances are measured as $R_1 = (100 \pm 3)\,\Omega$ and $R_2 = (200 \pm 4)\,\Omega$. When connected in series, the total resistance is: [JEE Main 2021]

(A) $(300 \pm 7)\,\Omega$

(B) $(300 \pm 1)\,\Omega$

(C) $(300 \pm 12)\,\Omega$

(D) $(300 \pm 3.5)\,\Omega$

**Q11.** A proton and an alpha particle enter a uniform magnetic field with the same velocity perpendicular to the field. The ratio of the radii of their circular paths is: [JEE Main 2023]

(A) 1:2

(B) 2:1

(C) 1:4

(D) 1:1

**Q12.** In an LCR series circuit, $L = 10\,\text{mH}$, $C = 1\,\mu\text{F}$ and $R = 10\,\Omega$. The quality factor (Q-factor) of the circuit is: [JEE Main 2024]

(A) 100

(B) 10

(C) 1

(D) 200

**Q13.** A square loop of side 10 cm and resistance 0.5 Ω is placed vertically in the east-west plane. A uniform magnetic field of 0.10 T is set up across the plane in the north-east direction. The magnetic field is decreased to zero in 0.70 s. The magnitude of induced current is: [JEE Main 2022]

(A) 1 mA

(B) 2 mA

(C) 3.5 mA

(D) 0.5 mA

**Q14.** A ray of light is incident at an angle of 60° on one face of a prism of angle 30°. The ray emerging from the prism makes an angle of 30° with the incident ray. The refractive index of the material is: [JEE Main 2019]

(A) $\sqrt{3}$

(B) 1.5

(C) $\sqrt{2}$

(D) 1.33

**Q15.** In a displacement method, the lengths of the images in the two positions of the lens are 9 cm and 4 cm. The length of the object is: [JEE Main 2023]

(A) 6 cm

(B) 5 cm

(C) 6.5 cm

(D) 36 cm

**Q16.** Two coherent sources of intensity ratio $\beta$ interfere. The ratio $\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$ is: [JEE Main 2021]

(A) $\frac{2\sqrt{\beta}}{1+\beta}$

(B) $\frac{\sqrt{\beta}}{1+\beta}$

(C) $\frac{2\sqrt{\beta}}{1-\beta}$

(D) $\frac{1+\beta}{2\sqrt{\beta}}$

**Q17.** An ideal gas is taken through a cyclic process ABCA. If the heat supplied in the process is 5 J, the work done by the gas in the process C $\rightarrow$ A is (given $W_{AB} = 10\,\text{J}, W_{BC} = 0\,\text{J}$): [JEE Main 2022]

(A) $-5\,\text{J}$

(B) $-15\,\text{J}$

(C) $15\,\text{J}$

(D) $5\,\text{J}$

**Q18.** The average translational kinetic energy of Nitrogen molecules at $27^{\circ}C$ is $6.21 \times 10^{-21}$ J. The average kinetic energy at $227^{\circ}C$ will be: [JEE Main 2021]

(A) $10.35 \times 10^{-21}\,\text{J}$

(B) $52.2 \times 10^{-21}\,\text{J}$

(C) $12.42 \times 10^{-21}\,\text{J}$

(D) $6.21 \times 10^{-21}\,\text{J}$

**Q19.** A simple pendulum has a time period $T_1$ on the earth's surface and $T_2$ when taken to a height $R$ above the earth's surface. The ratio $T_2/T_1$ is: [JEE Main 2020]

(A) 2

(B) 4

(C) $\sqrt{2}$

(D) 1/2

**Q20.** A transverse wave is represented by $y = A\sin(kx - \omega t)$. For what value of the wavelength is the maximum particle velocity equal to twice the wave velocity? [JEE Main 2021]

(A) $\pi A$

(B) $2\pi A$

(C) $\pi A/2$

(D) $A$

## Section B — Numerical Questions

**Q21.** A bullet of mass $10\,g$ moving with velocity $400\,m/s$ strikes a wood block and comes to rest after penetrating $5\,cm$. The average force exerted by the block on the bullet is $x \times 10^4\,N$. Find $x$. [JEE Main 2023]

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**Q22.** A satellite is revolving in a circular orbit at a height $h$ from the earth's surface. If the kinetic energy of the satellite is doubled, it escapes from the earth's gravity. The height $h$ is $R/x$. Find $x$ (Assume $R$ is radius of earth). [JEE Main 2022]

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**Q23.** A sphere of radius 10 cm and mass 2 kg is floating in water. The minimum mass that must be placed on it so that it just sinks is ____ kg. (Take $\rho_{\text{water}} = 1000\ \text{kg/m}^3, \pi = 3$). [JEE Main 2024]

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**Q24.** The density of a material in the shape of a cube is determined by measuring its mass and length of its side. If the relative errors in measuring the mass and length are 1.5% and 1% respectively, the maximum error in determining the density is ____%. [JEE Main 2021]

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**Q25.** A particle of mass $m$ is moving in a circular path of constant radius $r$ such that its centripetal acceleration $a_c$ is varying with time $t$ as $a_c = k^2rt^2$, where $k$ is a constant. The power delivered to the particle by the forces acting on it is $mk^xr^2t$. Find $x$. [JEE Main 2025]

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## Detailed Solutions

### Q1.

**Solution**

**Concept:** The longest wavelength of light that can cause photoelectron emission is given by the equation:

$$\lambda = \frac{hc}{eV_0}$$

where $h$ is Planck's constant, $c$ is the speed of light, and $V_0$ is the stopping potential. Using the work function $W = 4.0\,eV$, the wavelength can be calculated.

**Formula:**

$$\lambda = \frac{hc}{eV_0}$$

**Solution:** Substituting values into the formula, the wavelength of light that can cause photoelectron emission is approximately $310\,nm$.

**Final Answer:** The longest wavelength is $310\,nm$.

**Answer: (A)**

### Q2.

**Solution**

**Concept:** The de Broglie wavelength of an electron accelerated through a potential $V$ is given by:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

where $m_e$ is the mass of the electron and $e$ is the charge of the electron.

**Formula:**

$$\lambda = \frac{h}{\sqrt{2meV}}$$

**Solution:** For $V = 10,000\,V$, the de Broglie wavelength is calculated to be approximately $12.2 \times 10^{-12}\,m$.

**Final Answer:** The de Broglie wavelength is $12.2 \times 10^{-12}\,m$.

**Answer: (A)**

## Q3.

### Solution

**Concept:** The angular momentum of an electron in a hydrogen atom is quantized. The energy absorbed by the electron corresponds to a transition to a higher orbit, changing the angular momentum.

**Formula:**

$$L = n\hbar$$

**Solution:** The angular momentum change is $\Delta L = \hbar$, and thus the increase in angular momentum is $2.11 \times 10^{-34}\, J \cdot s$.

**Final Answer:** The increase in angular momentum is $2.11 \times 10^{-34}\, J \cdot s$.

**Answer: (B)**

## Q4.

### Solution

**Concept:** The time taken between 20

**Formula:**

$$t = T_{1/2} \ln\left(\frac{1}{1-x}\right)$$

**Solution:** For 20% to 80% decay, the time taken is calculated to be approximately 40 minutes.

**Final Answer:** The time taken is 40 minutes.

**Answer: (B)**

## Q5.

### Solution

**Concept:** The method of image charges is used for a point charge near a conducting plane. The image charge is placed at an equal distance on the opposite side.

**Formula:** The image charge is:

$$q_{\text{image}} = -q$$

**Solution:** The image charge is $-q$ at distance $2d$.

**Final Answer:** The image charge is $-q$ at distance $2d$.

**Answer: (C)**

## Q6.

### Solution

**Concept:** The capacitance of a parallel plate capacitor with a dielectric slab is given by the formula:

$$C = \frac{\epsilon_0 A}{d}$$

When a dielectric is inserted, the capacitance increases by a factor of $K$.

**Formula:**

$$C' = C + K$$

**Solution:** The new capacitance with the dielectric inserted is calculated to be 13.5 pF.

**Final Answer:** The new capacitance is $13.5\,pF$.

**Answer: (B)**

## Q7.

### Solution

**Concept:** The torque on a dipole in an electric field is given by:

$$\tau = pE\sin(\theta)$$

where $p$ is the dipole moment and $\theta$ is the angle.

**Formula:**

$$\tau = pE\sin(\theta)$$

**Solution:** Given the torque, we calculate the charge on the dipole as $5\,mC$.

**Final Answer:** The charge on the dipole is $5\,mC$.

**Answer: (B)**

## Q8.

### Solution

**Concept:** The voltage reading of a voltmeter depends on the resistance in the circuit and the potential divider rule.

**Formula:**

$$V = \frac{R}{R + R_2} V_{\text{source}}$$

**Solution:** The resistance of the voltmeter is found to be approximately 1200 Ω.

**Final Answer:** The resistance of the voltmeter is $1200\,\Omega$.

**Answer: (A)**

## Q9.

### Solution

**Concept:** The potential gradient of a potentiometer is the voltage drop across the wire per unit length.

**Formula:**

$$\text{Potential gradient} = \frac{V_{\text{battery}}}{\text{Total resistance}}$$

**Solution:** The potential gradient is calculated to be $0.2\,V/m$.

**Final Answer:** The potential gradient is $0.2\,V/m$.

**Answer: (A)**

## Q10.

### Solution

**Concept:** The total resistance of two resistances in series is the sum of their individual resistances.

**Formula:**

$$R_{\text{total}} = R_1 + R_2$$

**Solution:** The total resistance is $300\,\Omega$ with uncertainty of $7\,\Omega$.

**Final Answer:** The total resistance is $300\,\Omega \pm 7\,\Omega$.

**Answer: (A)**

## Q11.

### Solution

**Concept:** The radius of the circular path of a charged particle in a magnetic field is given by:

$$r = \frac{mv}{qB}$$

where $m$ is the mass, $v$ is the velocity, $q$ is the charge, and $B$ is the magnetic field.

**Formula:**

$$r_{\text{proton}} = \frac{m_{\text{proton}} v}{q_{\text{proton}} B}, \quad r_{\text{alpha}} = \frac{m_{\text{alpha}} v}{q_{\text{alpha}} B}$$

**Solution:** Using the mass and charge ratio, the radius ratio of proton to alpha particle is found to be 1:2.

**Final Answer:** The ratio is 1:2.

**Answer: (A)**

## Q12.

### Solution

**Concept:** The quality factor (Q-factor) of a series LCR circuit is given by:

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

**Formula:**

$$Q = \frac{1}{10}\sqrt{\frac{10\,mH}{1\,\mu F}}$$

**Solution:** The quality factor is calculated to be 100.

**Final Answer:** The Q-factor is 100.

**Answer: (A)**

## Q13.

### Solution

**Concept:** The induced current in a loop of wire in a changing magnetic field is given by Faraday's law:

$$\mathcal{E} = -\frac{d\Phi}{dt}$$

**Solution:** Using the values of magnetic field and time, the induced current is found to be $1\,mA$.

**Final Answer:** The induced current is $1\,mA$.

**Answer: (A)**

## Q14.

### Solution

**Concept:** The refractive index of the material is related to the angle of incidence and angle of refraction by Snell's law.

**Formula:**

$$n = \frac{\sin(i)}{\sin(r)}$$

**Solution:** Using the given angles, the refractive index is calculated to be $\sqrt{3}$.

**Final Answer:** The refractive index is $\sqrt{3}$.

**Answer: (A)**

## Q15.

### Solution

**Concept:** In the displacement method, the object length is determined from the image lengths using the lens formula.

**Formula:**

$$\text{Object length} = \text{Image length}$$

**Solution:** Using the given lengths, the object length is found to be $6\,cm$.

**Final Answer:** The object length is $6\,cm$.

**Answer: (A)**

## Q16.

### Solution

**Concept:** The intensity ratio of two coherent sources is related to the interference pattern by:

$$\frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} = \frac{2\sqrt{\beta}}{1+\beta}$$

**Solution:** Using the given intensity ratio, the final expression is found to be $\frac{2\sqrt{\beta}}{1+\beta}$.

**Final Answer:** The ratio is $\frac{2\sqrt{\beta}}{1+\beta}$.

**Answer: (A)**

## Q17.

### Solution

**Concept:** The work done in a cyclic process is related to the heat supplied and work done in each process.

**Formula:**

$$W = Q_{\text{in}} - Q_{\text{out}}$$

**Solution:** The work done in the process C to A is found to be $-5\,J$.

**Final Answer:** The work done is $-5\,J$.

**Answer: (A)**

## Q18.

### Solution

**Concept:** The average kinetic energy is proportional to the temperature.
**Solution:** The average kinetic energy at $227^{\circ}C$ is calculated to be $10.35 \times 10^{-21}\ J$.
**Final Answer:** The average kinetic energy is $10.35 \times 10^{-21}\ J$.

**Answer: (A)**

## Q19.

### Solution

**Concept:** The time period of a pendulum is dependent on the acceleration due to gravity at the given height.
**Solution:** The ratio $T_2/T_1$ is found to be $\sqrt{2}$.
**Final Answer:** The ratio $T_2/T_1$ is $\sqrt{2}$.

**Answer: (C)**

## Q20.

### Solution

**Concept:** The particle velocity is related to the wave velocity by the relationship for transverse waves.
**Solution:** The wavelength required for the maximum particle velocity to be twice the wave velocity is $\pi A$.
**Final Answer:** The wavelength is $\pi A$.

**Answer: (A)**

## Q21.

### Solution

**Concept:** The work done by the force exerted by the block on the bullet can be calculated using the work-energy theorem:

$$W = F \cdot d$$

where $F$ is the average force, and $d$ is the displacement. The work done by the force is equal to the change in kinetic energy of the bullet.

**Formula:**

$$F = \frac{mv^2}{2d}$$

**Solution:** Given that the mass $m = 10\,g = 0.01\,kg$, velocity $v = 400\,m/s$, and displacement $d = 5\,cm = 0.05\,m$, we calculate the average force:

$$F = \frac{(0.01) \times (400)^2}{2 \times 0.05} = 1.6 \times 10^4\,N$$

**Final Answer:** The average force exerted by the block on the bullet is $x = 1.6$.

**Answer: (1.6)**

## Q22.

### Solution

**Concept:** The escape velocity of a satellite is given by the equation:

$$v_e = \sqrt{\frac{2GM}{r}}$$

where $r$ is the radius of the orbit and $M$ is the mass of the earth. The kinetic energy of a satellite is directly proportional to its velocity.

**Formula:**

$$KE = \frac{1}{2}mv_e^2$$

**Solution:** When the kinetic energy is doubled, the satellite escapes from the earth's gravity, meaning it reaches the escape velocity. The height $h$ is related to the radius by $h = R/x$, where $R$ is the radius of the earth.

**Final Answer:** $x = 2$.

**Answer: (2)**

## Q23.

### Solution

**Concept:** The buoyancy condition for a floating body is given by Archimedes' principle:

$$\text{Buoyant force} = \text{Weight of displaced water}$$

The volume of water displaced is equal to the volume of the submerged part of the sphere, which is $V = \frac{4}{3}\pi r^3$.

**Formula:**

$$\text{Weight of displaced water} = \rho_{\text{water}} \cdot V \cdot g$$

**Solution:** For the sphere to just sink, the weight of the sphere plus the added mass $m$ equals the buoyant force. Using the given values, we find the minimum mass to be $m = 0.25\,kg$.

**Final Answer:** The minimum mass that must be placed on the sphere to just sink is $0.25\,kg$.

**Answer: (0.25)**

## Q24.

### Solution

**Concept:** The error in density can be calculated using the relative errors in mass and length. The density $\rho$ is given by:

$$\rho = \frac{m}{L^3}$$

The maximum error in density is the sum of the relative errors in mass and the length, multiplied by their respective powers.

**Formula:**

$$\text{Maximum error in density} = \text{Relative error in mass} + 3 \times \text{Relative error in length}$$

**Solution:** Given the relative errors, the maximum error in density is:

$$\text{Maximum error in density} = 1.5\% + 3 \times 1\% = 4.5\%$$

**Final Answer:** The maximum error in determining the density is 4.5%.

**Answer: (4.5)**

## Q25.

### Solution

**Concept:** The power delivered to the particle is given by the rate of work done on it. The work done is related to the change in kinetic energy, and the power can be expressed as:

$$P = \frac{dW}{dt}$$

**Formula:**

$$P = ma_c v$$

**Solution:** Since the centripetal acceleration $a_c = k^2rt^2$, the power delivered to the particle is given by:

$$P = mk^x r^2 t$$

Using dimensional analysis, we find that $x = 3$.

**Final Answer:** The power delivered to the particle is $mk^3r^2t$.

**Answer: (3)**

## Answer Key — Section A

| Q | Ans | Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | 2 | A | 3 | B | 4 | B | 5 | C |
| 6 | B | 7 | B | 8 | A | 9 | A | 10 | A |
| 11 | A | 12 | A | 13 | A | 14 | A | 15 | A |
| 16 | A | 17 | A | 18 | A | 19 | C | 20 | A |

## Answer Key — Section B

| Q | Ans | Q | Ans |
|---|---|---|---|
| 21 | 1.6 | 22 | 2 |
| 23 | 0.25 | 24 | 4.5 |
| 25 | 3 | | |