

JEE Main Physics Sample Paper-13

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 energy required to excite an electron in a hydrogen atom from the first orbit to the second orbit is [JEE Main 2024]
- (A) 13.6 eV
(B) 3.4 eV
(C) 10.2 eV
(D) 1.4 eV
- Q2.** In a photoelectric effect experiment, the cutoff frequency of the material is 5×10^{14} Hz. If the frequency of the incident light is 1.5×10^{15} Hz, then the maximum kinetic energy of the photoelectron is [JEE Main 2022]
- (A) 1.5 eV
(B) 2 eV
(C) 3 eV
(D) 4 eV
- Q3.** The time period of a simple pendulum is T . If the mass of the bob is doubled, the new time period is [JEE Main 2023]
- (A) T



- (B) $2T$
- (C) $\sqrt{2}T$
- (D) $T/\sqrt{2}$

Q4. The capacitance of a capacitor increases when

[JEE Main 2021]

- (A) The area of the plates is reduced
- (B) The distance between the plates is increased
- (C) A dielectric is inserted between the plates
- (D) The potential difference is increased

Q5. In a circuit with three resistors of resistance $2\ \Omega$, $3\ \Omega$, and $6\ \Omega$ connected in series, the total resistance is

[JEE Main 2024]

- (A) $1\ \Omega$
- (B) $3\ \Omega$
- (C) $5\ \Omega$
- (D) $11\ \Omega$

Q6. The current in an AC circuit is given by $I = I_0 \sin(\omega t)$. If the current at time $t = 0$ is $0.5\ \text{A}$ and the maximum current is $1\ \text{A}$, the phase angle between the current and the voltage is

[JEE Main 2022]

- (A) 0°
- (B) 30°
- (C) 45°
- (D) 90°

Q7. A magnet is brought near a conducting loop. The induced current in the loop depends on

[JEE Main 2023]

- (A) The rate of change of magnetic flux through the loop
- (B) The area of the loop
- (C) The resistance of the loop
- (D) All of the above



- Q8.** In Young's double-slit experiment, the intensity of the central maximum is I_0 . If the slit width is halved, the new intensity of the central maximum is [JEE Main 2021]
- (A) $I_0/2$
(B) I_0
(C) $2I_0$
(D) $I_0/4$
- Q9.** The magnetic field at the center of a circular current-carrying loop is given by $B = \mu_0 I/2R$. If the current is halved and the radius is doubled, the magnetic field at the center becomes [JEE Main 2023]
- (A) $\mu_0 I/4R$
(B) $\mu_0 I/2R$
(C) $\mu_0 I/R$
(D) $\mu_0 I/8R$
- Q10.** The focal length of a lens is 20 cm. An object is placed at a distance of 30 cm. The image distance is [JEE Main 2022]
- (A) 60 cm
(B) 30 cm
(C) -60 cm
(D) -30 cm
- Q11.** The velocity of a particle moving in a circular orbit is 2 m/s. If the radius of the orbit is doubled, the speed of the particle will become [JEE Main 2021]
- (A) $\sqrt{2}$ m/s
(B) 2 m/s
(C) 4 m/s
(D) $\sqrt{4}$ m/s
- Q12.** The moment of inertia of a solid sphere about an axis passing through its center is [JEE Main 2022]
- (A) $\frac{1}{2}MR^2$



(B) $\frac{2}{5}MR^2$

(C) $\frac{3}{5}MR^2$

(D) $\frac{1}{4}MR^2$

Q13. The RMS speed of gas molecules is proportional to the square root of temperature. If the temperature is tripled, the RMS speed becomes [\[JEE Main 2024\]](#)

(A) 3 times

(B) 9 times

(C) 27 times

(D) $\sqrt{3}$ times

Q14. The work done in stretching a spring is proportional to [\[JEE Main 2023\]](#)

(A) Displacement

(B) Square of the displacement

(C) Cube of the displacement

(D) Inverse of the displacement

Q15. A charge Q is placed at the center of a spherical shell. The electric field at a point outside the shell is [\[JEE Main 2022\]](#)

(A) Zero

(B) Directly proportional to the distance from the shell

(C) Inversely proportional to the square of the distance from the shell

(D) Dependent on the shell's radius

Q16. The period of a mass attached to a spring is 2 s. If the mass is doubled, the new period will be [\[JEE Main 2024\]](#)

(A) 4 s

(B) $\sqrt{2}$ s

(C) 2 s

(D) 3 s

Q17. The frequency of oscillation of a body in SHM depends on [\[JEE Main 2023\]](#)



- (A) Amplitude
- (B) Mass
- (C) Spring constant
- (D) Force acting on the body

Q18. A satellite is in orbit at a height equal to the radius of the Earth. The acceleration due to gravity on the satellite is [JEE Main 2022]

- (A) $g/4$
- (B) $g/2$
- (C) g
- (D) $g/3$

Q19. The gravitational potential energy of a mass at the Earth's surface is U . At a height $h = R$ from the Earth's surface, the potential energy is [JEE Main 2024]

- (A) $U/2$
- (B) $U/3$
- (C) U
- (D) $U/4$

Q20. The speed of a wave is 100 m/s, and its frequency is 50 Hz. The wavelength of the wave is [JEE Main 2023]

- (A) 1 m
- (B) 2 m
- (C) 5 m
- (D) 10 m



Section B — Numerical Questions

- Q21.** A capacitor of $12 \mu\text{F}$ is charged to 10 V . What is the energy stored in the capacitor? [JEE Main 2024]
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- Q22.** A mass of 5 kg is moving with a velocity of 10 m/s . It collides elastically with a wall. Find the speed of the mass after the collision. [JEE Main 2023]
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- Q23.** A 3-kg block is sliding on a frictionless surface with a velocity of 4 m/s . Calculate the kinetic energy of the block. [JEE Main 2022]
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- Q24.** The spring constant of a spring is 400 N/m . The spring is stretched by 0.1 m . Find the force required to stretch the spring. [JEE Main 2021]
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- Q25.** A body is thrown vertically upwards with an initial velocity of 20 m/s . Find the maximum height attained by the body. [JEE Main 2024]
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Detailed Solutions

Q1.

Solution

Concept: The energy required to excite an electron from the first orbit to the second orbit in a hydrogen atom is calculated using the energy levels for hydrogen. The energy required is given by:

$$E = 13.6 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

For the transition from $n = 1$ to $n = 2$, the energy required is $13.6 \left(1 - \frac{1}{4} \right) = 10.2 \text{ eV}$.

Solution: The energy required to excite an electron from the first orbit to the second orbit is 10.2 eV .

Answer: (C)

Q2.

Solution

Concept: In the photoelectric effect, the maximum kinetic energy of the emitted photoelectron is given by:

$$KE_{\max} = hf - \phi$$

where f is the frequency of the incident light, and $\phi = h \times f_0$ is the work function of the material. Given: $f = 1.5 \times 10^{15} \text{ Hz}$, $f_0 = 5 \times 10^{14} \text{ Hz}$, $\phi = h \times f_0$.

The maximum kinetic energy of the emitted photoelectron is:

$$KE_{\max} = h \times (f - f_0) = 6.626 \times 10^{-34} \times (1.5 \times 10^{15} - 5 \times 10^{14})$$

$$KE_{\max} = 6.626 \times 10^{-34} \times 1 \times 10^{15} = 4 \text{ eV}$$

Solution: The maximum kinetic energy of the photoelectron is 4 eV .

Answer: (D)

Q3.

Solution

Concept: The time period T of a simple pendulum is given by:

$$T = 2\pi \sqrt{\frac{L}{g}}$$

where L is the length of the pendulum, and $g = 9.8 \text{ m/s}^2$ is the acceleration due to gravity. The time period is independent of the mass of the bob, so doubling the mass does not change the time period.

Solution: The new time period remains T .

Answer: (A)



Q4.

Solution**Concept:** The capacitance of a capacitor is given by:

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

where A is the area of the plates, d is the distance between them, and ϵ_0 is the permittivity of free space. - If the area is reduced, the capacitance decreases. - If the distance between the plates increases, the capacitance decreases. - If a dielectric is inserted between the plates, the capacitance increases.

Solution: The capacitance increases when a dielectric is inserted between the plates.**Answer: (C)**

Q5.

Solution**Concept:** The total resistance in a series combination of resistors is the sum of their individual resistances:

$$R_{\text{total}} = R_1 + R_2 + R_3$$

Given $R_1 = 2 \Omega$, $R_2 = 3 \Omega$, and $R_3 = 6 \Omega$, the total resistance is:

$$R_{\text{total}} = 2 + 3 + 6 = 11 \Omega$$

Solution: The total resistance in the series combination is 11Ω .**Answer: (D)**

Q6.

Solution**Concept:** The current in an AC circuit is given by $I = I_0 \sin(\omega t)$. At $t = 0$, the current is $I_0 \sin(0) = 0$. The phase angle between the current and voltage is ϕ , and the maximum current occurs when $\sin(\omega t) = 1$.**Solution:** Since the current at $t = 0$ is given, it indicates that the phase angle between the current and voltage is 0° .**Answer: (A)**

Q7.

Solution

Concept: In the case of electromagnetic induction, the induced current depends on the rate of change of magnetic flux through the loop. - The area of the loop also affects the induced current. - The resistance of the loop will affect the magnitude of the induced current.

Solution: The induced current depends on all of the above factors: the rate of change of magnetic flux, the area of the loop, and the resistance of the loop.

Answer: (D)

Q8.

Solution

Concept: In Young's double-slit experiment, the intensity of the central maximum is given by I_0 . - If the slit width is halved, the diffraction pattern becomes wider, reducing the intensity of the central maximum.

Solution: The intensity of the central maximum becomes $I_0/4$.

Answer: (D)

Q9.

Solution

Concept: The magnetic field at the center of a circular loop of current is given by:

$$B = \frac{\mu_0 I}{2R}$$

If the current is halved and the radius is doubled, the new magnetic field is:

$$B_{\text{new}} = \frac{\mu_0 \times \frac{I}{2}}{2R} = \frac{B}{4}$$

Solution: The magnetic field at the center of the loop becomes $B/8$.

Answer: (D)

Q10.

Solution

Concept: The focal length of a lens is related to the object distance u and image distance v by the lens formula:

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

For $f = 20$ cm and $u = -30$ cm, we can solve for v .

Solution: The image distance is found to be -60 cm.

Answer: (C)

Q11.

Solution

Concept: The velocity of a particle moving in a circular orbit is related to the radius r by the equation:

$$v = \sqrt{\frac{GM}{r}}$$

If the radius of the orbit is doubled, the speed of the particle becomes:

$$v_{\text{new}} = \frac{v}{\sqrt{2}}$$

Solution: When the radius is doubled, the speed decreases by a factor of $\sqrt{2}$.

Answer: (A)

Q12.

Solution

Concept: The moment of inertia I for a solid sphere about an axis through its center is given by:

$$I = \frac{2}{5}MR^2$$

where M is the mass and R is the radius of the sphere.

Solution: The moment of inertia for a solid sphere about an axis through its center is $\frac{2}{5}MR^2$.

Answer: (B)



Q13.

Solution

Concept: The RMS speed of gas molecules is proportional to the square root of the temperature:

$$v_{\text{rms}} \propto \sqrt{T}$$

If the temperature is tripled, the RMS speed will increase by a factor of $\sqrt{3}$.

Solution: The RMS speed becomes $\sqrt{3}$ times the original speed.

Answer: (D)

Q14.

Solution

Concept: The work done in stretching a spring is proportional to the square of the displacement:

$$W \propto x^2$$

Solution: The work done in stretching a spring is proportional to the square of the displacement.

Answer: (B)

Q15.

Solution

Concept: The electric field at a point outside a spherical shell with a point charge Q at its center is the same as if the charge were located at the center of the shell, due to the spherical symmetry.

Solution: The electric field outside the shell is the same as the field due to a point charge located at the center.

Answer: (C)

Q16.

Solution

Concept: The time period T of a mass attached to a spring in SHM is given by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

If the mass is doubled, the new time period is $T_{\text{new}} = 2T$.

Solution: The new time period is 2s.

Answer: (B)



Q17.

Solution

Concept: The frequency of oscillation of a body in SHM depends on the spring constant and mass:

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

where k is the spring constant and m is the mass.

Solution: The frequency depends on the spring constant.

Answer: (C)

Q18.

Solution

Concept: The acceleration due to gravity at a height $h = R$ from the Earth's surface is given by:

$$g_{\text{new}} = \frac{g}{4}$$

Solution: The acceleration due to gravity at the satellite's height is $g/4$.

Answer: (A)

Q19.

Solution

Concept: The gravitational potential energy at the Earth's surface is $U = -\frac{GMm}{R}$. At a height $h = R$, the potential energy is:

$$U_{\text{new}} = -\frac{GMm}{2R}$$

Solution: The potential energy at the height $h = R$ is $U/2$.

Answer: (A)

Q20.

Solution

Concept: The wavelength λ of a wave is given by:

$$\lambda = \frac{v}{f}$$

where $v = 100$ m/s is the speed of the wave and $f = 50$ Hz is the frequency.

Solution: The wavelength is:

$$\lambda = \frac{100}{50} = 2 \text{ m}$$

Answer: (B)



Q21.

Solution**Concept:** The energy stored in a capacitor is given by:

$$E = \frac{1}{2}CV^2$$

where $C = 12 \mu\text{F} = 12 \times 10^{-6} \text{ F}$ and $V = 10 \text{ V}$.**Solution:** Substitute the given values into the formula:

$$E = \frac{1}{2} \times 12 \times 10^{-6} \times (10)^2 = 6 \times 10^{-4} \text{ J}$$

Answer: (6×10^{-4})

Q22.

Solution**Concept:** In an elastic collision, the velocity of the mass is reversed, but the magnitude of the velocity remains the same. The speed after the collision will be the same as the initial speed but in the opposite direction.**Solution:** Since the collision is elastic, the speed of the mass after collision is the same as before, but in the opposite direction. Therefore, the speed after the collision is 10 m/s.**Answer:** (10)

Q23.

Solution**Concept:** The kinetic energy of an object is given by:

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

where $m = 3 \text{ kg}$ and $v = 4 \text{ m/s}$.**Solution:** Substitute the given values into the formula:

$$KE = \frac{1}{2} \times 3 \times (4)^2 = \frac{1}{2} \times 3 \times 16 = 24 \text{ J}$$

Answer: (24)

Q24.

Solution

Concept: The force required to stretch a spring is given by Hooke's Law:

$$F = kx$$

where $k = 400 \text{ N/m}$ is the spring constant, and $x = 0.1 \text{ m}$ is the extension.

Solution: Substitute the given values into the formula:

$$F = 400 \times 0.1 = 40 \text{ N}$$

Answer: (40)

Q25.

Solution

Concept: The maximum height h attained by the body thrown vertically upwards is given by the kinematic equation:

$$v^2 = u^2 - 2gh$$

where: - $v = 0 \text{ m/s}$ (final velocity at maximum height), - $u = 20 \text{ m/s}$ (initial velocity), - $g = 9.8 \text{ m/s}^2$ (acceleration due to gravity).

Solution: Rearranging the formula to solve for h :

$$h = \frac{u^2}{2g} = \frac{(20)^2}{2 \times 9.8} = \frac{400}{19.6} = 20.41 \text{ m}$$

Answer: (20.41)



Answer Key — Section A

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

Answer Key — Section B

Q	Ans	Q	Ans
21	6×10^{-4}	22	10
23	24	24	40
25	20.41		

