JEECUP Sample Paper

Physics (Group A) - Paper 3

Duration: 37 Minutes **Maximum Marks: 100**

Instructions

- This paper contains **25** Multiple Choice Questions from the Physics section of the JEECUP Group A syllabus.
- Each correct answer carries **+4 marks**. There is **no negative marking** - attempt every question.
- Only **one** option is correct. Maximum marks: **100**. Total duration: **37 minutes** (Physics-only).
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Physics: 25 Questions

Q1. A particle moving in a straight line covers $40\,\mathrm{m}$ in $5\,\mathrm{s}$ and the next $60\,\mathrm{m}$ in $5\,\mathrm{s}$. Its average speed is:

(A) $8\,\mathrm{m\,s^{-1}}$

(B) $10\,\mathrm{m\,s^{-1}}$

(C) $12\,\mathrm{m\,s^{-1}}$

(D) $20\,\mathrm{m\,s^{-1}}$

Q2. The acceleration of a freely falling body near the Earth's surface is:

(A) Zero

(B) g, downward

(C) g, upward

(D) Depends on mass

Q3. A car covers half its distance at $60\,\mathrm{km/h}$ and the other half at $40\,\mathrm{km/h}$. Its average speed is:

(A) $48\,\mathrm{km/h}$

(B) $50\,\mathrm{km/h}$

(C) $55\,\mathrm{km/h}$

(D) $52\,\mathrm{km/h}$

Q4. Newton's second law gives:

(A) $F = m + a$

(B) $F = ma$

(C) $F = m/a$

(D) $F = a/m$

Q5. A spring of force constant $200\,\mathrm{N/m}$ is stretched by $0.1\,\mathrm{m}$. The energy stored is:

(A) $0.5\,\mathrm{J}$

(B) $1\,\mathrm{J}$

(C) $2\,\mathrm{J}$

(D) $20\,\mathrm{J}$

Q6. A ball is dropped onto a hard floor and rebounds to half its original height. The fraction of energy lost is:

(A) 25%

(B) 50%

(C) 75%

(D) 100%

Q7. Kepler's second law (areal velocity) is a consequence of conservation of:

(A) Energy

(B) Mass

(C) Angular momentum

(D) Linear momentum

Q8. A bus moves on a horizontal circular track of radius $50\,\mathrm{m}$ at $10\,\mathrm{m/s}$. The centripetal acceleration is:

(A) $1\,\mathrm{m\,s^{-2}}$

(B) $2\,\mathrm{m\,s^{-2}}$

(C) $5\,\mathrm{m\,s^{-2}}$

(D) $10\,\mathrm{m\,s^{-2}}$

Q9. A rod of length $1\,\mathrm{m}$ expands by $1\,\mathrm{mm}$ when heated by $50°\mathrm{C}$. The coefficient of linear expansion is:

(A) $2 \times 10^{-5}\,\mathrm{K^{-1}}$

(B) $5 \times 10^{-5}\,\mathrm{K^{-1}}$

(C) $1 \times 10^{-5}\,\mathrm{K^{-1}}$

(D) $1 \times 10^{-4}\,\mathrm{K^{-1}}$

Q10. During an adiabatic process for an ideal gas:

(A) Heat absorbed is maximum

(B) No heat is exchanged

(C) Temperature stays constant

(D) Work done is zero

Q11. Boyle's law states that at constant temperature, the pressure of a fixed mass of gas is:

(A) Directly proportional to volume

(B) Inversely proportional to volume

(C) Independent of volume

(D) Proportional to V^2

Q12. An object placed at $2f$ in front of a convex lens forms an image:

(A) At f, real, inverted

(B) At $2f$, real, inverted, same size

(C) At infinity, virtual

(D) At $f/2$, real, magnified

Q13. The dispersion of white light by a prism is due to:

(A) Reflection

(B) Refractive index varying with wavelength

(C) Polarisation

(D) Diffraction

Q14. A defective eye that cannot see distant objects clearly is corrected using:

(A) Convex lens

(B) Concave lens

(C) Cylindrical lens

(D) Bifocal lens

Q15. Two thin lenses of focal lengths $20\,\mathrm{cm}$ and $30\,\mathrm{cm}$ are placed in contact. The combined focal length is:

(A) $50\,\mathrm{cm}$

(B) $12\,\mathrm{cm}$

(C) $10\,\mathrm{cm}$

(D) $25\,\mathrm{cm}$

Q16. A wire carries $5\,\mathrm{A}$ for $20\,\mathrm{s}$. The charge that flows is:

(A) $25\,\mathrm{C}$

(B) $100\,\mathrm{C}$

(C) $4\,\mathrm{C}$

(D) $1000\,\mathrm{C}$

Q17. The resistance of a conductor at $0°\mathrm{C}$ is $5\,\Omega$ and temperature coefficient $\alpha = 0.004\,\mathrm{K}^{-1}$. Resistance at $100°\mathrm{C}$ is:

(A) $5.4\,\Omega$

(B) $7\,\Omega$

(C) $5.04\,\Omega$

(D) $9\,\Omega$

Q18. A long straight wire carries current I. The magnetic field at distance r is:

(A) $\mu_0 I/r$

(B) $\mu_0 I/(2\pi r)$

(C) $\mu_0 I/(2r)$

(D) $\mu_0 Ir/2$

Q19. AC has frequency $50\,\text{Hz}$. Its time period is:

(A) $0.02\,\text{s}$

(B) $0.5\,\text{s}$

(C) $1\,\text{s}$

(D) $50\,\text{s}$

Q20. The wavelength corresponding to the Balmer series limit of hydrogen falls in the:

(A) Radio

(B) Visible

(C) Ultraviolet

(D) Infrared

Q21. A radioactive isotope has decay constant $\lambda = 0.0693\,\text{min}^{-1}$. Its half-life is approximately:

(A) $5\,\text{min}$

(B) $10\,\text{min}$

(C) $20\,\text{min}$

(D) $50\,\text{min}$

Q22. For a particle executing SHM, the acceleration is:

(A) Constant

(B) Proportional to displacement (and opposite in direction)

(C) Proportional to $\sqrt{\text{displacement}}$

(D) Independent of displacement

Q23. A $10\,\mu\text{F}$ capacitor is connected to a $50\,\text{V}$ source. The charge stored is:

(A) $0.0005\,\text{C}$

(B) $0.05\,\text{C}$

(C) $5\,\text{C}$

(D) $50\,\text{C}$

Q24. A semiconductor in which holes are majority carriers is called:

(A) N-type

(B) P-type

(C) Intrinsic

(D) Insulator

Q25. The SI unit of magnetic flux is:

(A) Tesla

(B) Weber

(C) Henry

(D) Ampere

Solutions

Q1. Average speed over a multi-leg journey.

Solution

Concept. Average speed is the total distance traveled divided by the total time elapsed - NOT the arithmetic mean of two leg speeds (that would only equal the true average if the leg *times* are equal, which is the case here).

Given. Leg 1: $40\,\mathrm{m}$ in $5\,\mathrm{s}$. Leg 2: $60\,\mathrm{m}$ in $5\,\mathrm{s}$.

Step 1. Total distance $D = 40 + 60 = 100\,\mathrm{m}$.

Step 2. Total time $T = 5 + 5 = 10\,\mathrm{s}$.

Step 3. Average speed $\bar{v} = D/T = 100/10 = 10\,\mathrm{m\,s^{-1}}$.

Answer: (B)

← Go back to Q1

Q2. Free-fall acceleration.

Solution

Concept. Galileo's principle: in the absence of air resistance, all bodies near the Earth's surface fall with the same acceleration $g \approx 9.8\,\mathrm{m\,s^{-2}}$, directed toward the Earth's centre (i.e., downward). The acceleration is independent of mass, shape, or composition - this is the basis of the equivalence principle.

Step 1. The direction must be downward, because gravity pulls toward Earth's centre.

Step 2. The magnitude is g, the same for all freely falling bodies.

Cross-check. Famously demonstrated by the Apollo 15 hammer-feather drop on the Moon (no atmosphere) - both hit the ground at the same time.

Answer: (B)

← Go back to Q2

Q3. Average speed over equal distances (harmonic mean).

Solution

Concept. When equal *distances* are covered at different speeds, the average speed is the harmonic mean: $\bar{v} = \dfrac{2v_1v_2}{v_1 + v_2}$. This is always LESS than the arithmetic mean - because more time is spent on the slower leg.

Given. $v_1 = 60\,\mathrm{km/h}$ for the first half-distance; $v_2 = 40\,\mathrm{km/h}$ for the second half-distance.

Step 1. Apply the harmonic-mean formula: $\bar{v} = \dfrac{2 \cdot 60 \cdot 40}{60 + 40}$.

Step 2. Simplify numerator: $2 \cdot 60 \cdot 40 = 4800$.

Step 3. Simplify denominator: $60 + 40 = 100$.

Step 4. Divide: $\bar{v} = 4800/100 = 48\,\text{km/h}$. (Note: $48 < 50$, the arithmetic mean - matches the expectation.)

Answer: (A)

← Go back to Q3

Q4. Newton's second law.

Solution

Concept. Newton's second law in its scalar form (constant mass) reads $F = ma$, where F is the net force, m is the mass (a measure of inertia), and a is the acceleration produced. In its full form: $\vec{F} = d\vec{p}/dt$, which reduces to $\vec{F} = m\vec{a}$ when mass doesn't change.

Step 1. Of the listed options, only $F = ma$ matches the textbook statement.

Sanity check via units. $[\text{N}] = [\text{kg}] \cdot [\text{m}\,\text{s}^{-2}]$ - confirms $F = ma$ is dimensionally correct.

Answer: (B)

← Go back to Q4

Q5. Elastic potential energy stored in a stretched spring.

Solution

Concept. A spring obeying Hooke's law ($F = kx$) stores elastic potential energy $U = \frac{1}{2}kx^2$, where x is the extension (or compression) from equilibrium and k is the spring constant.

Given. $k = 200\,\text{N/m}$; $x = 0.1\,\text{m}$.

Step 1. Apply $U = \frac{1}{2}kx^2$.

Step 2. Compute $x^2 = (0.1)^2 = 0.01$.

Step 3. Substitute: $U = 0.5 \times 200 \times 0.01$.

Step 4. Compute: $U = 100 \times 0.01 = 1\,\text{J}$.

Answer: (B)

← Go back to Q5

Q6. Energy lost in an inelastic bounce.

Solution

Concept. Just before impact, the ball has $\mathrm{KE} = mgh_1$ (= original PE). Just after, $\mathrm{KE}' = mgh_2$ (= new PE). The fraction of energy retained equals h_2/h_1; the fraction lost equals $1 - h_2/h_1$.

Given. $h_2 = h_1/2$.

Step 1. Fraction retained: $h_2/h_1 = 1/2$, i.e. 50%.

Step 2. Fraction lost: $1 - 1/2 = 1/2$, i.e. 50%.

Answer: (B)

← Go back to Q6

Q7. Origin of Kepler's second law.

Solution

Concept. Kepler's second law states that the line joining a planet to the Sun sweeps out equal areas in equal times. Mathematically, $dA/dt = L/(2m)$ where L is the orbital angular momentum. Since gravity is a CENTRAL force (always pointing along the radial line), it exerts NO torque about the Sun, so angular momentum L is conserved.

Step 1. Constant $L \Leftrightarrow$ constant areal velocity $dA/dt \Leftrightarrow$ Kepler's second law.

Step 2. So the underlying conservation law here is conservation of angular momentum.

Answer: (C)

← Go back to Q7

Q8. Centripetal acceleration on a circular track.

Solution

Concept. A body moving in a circle at constant speed has acceleration directed toward the centre, with magnitude $a_c = v^2/r$.

Given. Speed $v = 10\,\mathrm{m/s}$; radius $r = 50\,\mathrm{m}$.

Step 1. Apply $a_c = v^2/r$.

Step 2. Substitute: $a_c = (10)^2/50 = 100/50$.

Step 3. Compute: $a_c = 2\,\mathrm{m\,s^{-2}}$.

Answer: (B)

← Go back to Q8

Q9. Coefficient of linear thermal expansion.

Solution

Concept. A solid rod's length changes with temperature as $\Delta L = L_0 \alpha \Delta T$, where α is the coefficient of linear expansion. Rearranging: $\alpha = \Delta L/(L_0 \Delta T)$.

Given. $L_0 = 1\,\text{m}$; $\Delta L = 1\,\text{mm} = 10^{-3}\,\text{m}$; $\Delta T = 50\,°\text{C} = 50\,\text{K}$ (Kelvin and Celsius intervals are equal).

Step 1. Substitute: $\alpha = 10^{-3}/(1 \times 50)$.

Step 2. Compute: $\alpha = 2 \times 10^{-5}\,\text{K}^{-1}$. (This is roughly the expansion of steel; close enough for a "physics rod".)

Answer: (A)

← Go back to Q9

Q10. Adiabatic process.

Solution

Concept. An adiabatic process is, by definition, a thermodynamic process in which NO heat is exchanged between the system and its surroundings: $Q = 0$. The system's temperature can still change (e.g. the gas cools during an adiabatic expansion), but all the energy change comes from work, not heat.

Step 1. Of the options: heat exchange $\neq$ zero is "isobaric" or general. Temperature constant is isothermal. Work done zero is isochoric. Only "no heat exchanged" matches adiabatic.

Answer: (B)

← Go back to Q10

Q11. Boyle's law.

Solution

Concept. For a fixed mass of ideal gas at constant temperature, pressure and volume are inversely proportional: $PV =$ constant, or equivalently $P \propto 1/V$.

Step 1. As V increases, P decreases proportionally - inverse proportion is the answer.

Step 2. The other options describe Charles's law (direct in V vs T), constant-volume processes, etc., not Boyle's law.

Answer: (B)

← Go back to Q11

Q12. Object at $2f$ from a convex lens.

Solution

Concept. Using the lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ with sign convention: an object at distance $2f$ on the incoming side has $u = -2f$. A convex lens has $f > 0$.

Step 1. Substitute: $\frac{1}{v} - \frac{1}{-2f} = \frac{1}{f}$, i.e. $\frac{1}{v} = \frac{1}{f} - \frac{1}{2f} = \frac{2-1}{2f} = \frac{1}{2f}$.

Step 2. So $v = +2f$ - image at $2f$ on the other side of the lens.

Step 3. Magnification $m = v/u = 2f/(-2f) = -1$ - inverted and same size.

Answer: (B)

← Go back to Q12

Q13. Origin of dispersion in a prism.

Solution

Concept. A prism's refractive index $n(\lambda)$ depends slightly on wavelength - blue light has a higher n than red. Snell's law applied at the prism faces therefore bends each colour by a different amount, splitting the white incident ray into its spectral components.

Step 1. Reflection, polarisation, and diffraction are all other optical phenomena, but the colour-spreading in a prism is specifically refraction-with-wavelength-dependent-index, i.e. *dispersion*.

Step 2. Therefore the correct answer is "refractive index varying with wavelength".

Answer: (B)

← Go back to Q13

Q14. Correction for myopia (near-sightedness).

Solution

Concept. A myopic eye focuses parallel rays from distant objects in FRONT of the retina - the eyeball is "too long" or the lens "too powerful". To shift the image back onto the retina, we need a diverging (concave) lens to spread the rays first.

Step 1. A concave lens has negative power, diverging the rays slightly so they re-converge exactly at the retina.

Step 2. A convex lens would converge them even sooner - worsening myopia. A cylindrical lens corrects astigmatism. A bifocal lens corrects both near AND far defects in older patients.

Answer: (B)

← Go back to Q14

Q15. Two thin lenses in contact.

Solution

Concept. For two thin lenses placed in close contact, the powers ADD: $P = P_1 + P_2$, or equivalently $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$. This is just because the rays exit lens 1 and immediately enter lens 2 with the same height (no separation).

Given. $f_1 = 20\,\text{cm}$; $f_2 = 30\,\text{cm}$.

Step 1. Compute $1/f = 1/20 + 1/30$.

Step 2. Common denominator 60: $1/f = 3/60 + 2/60 = 5/60 = 1/12$.

Step 3. Therefore $f = 12\,\text{cm}$.

Answer: (B)

← Go back to Q15

Q16. Charge flowing in a wire.

Solution

Concept. Current is the rate of flow of charge: $I = Q/t$, so $Q = I \cdot t$.

Given. $I = 5\,\text{A}$; $t = 20\,\text{s}$.

Step 1. Apply $Q = It$.

Step 2. Substitute: $Q = 5 \times 20$.

Step 3. Compute: $Q = 100\,\text{C}$.

Answer: (B)

← Go back to Q16

Q17. Resistance variation with temperature.

Solution

Concept. For a metal conductor, the resistance varies approximately linearly with temperature: $R_T = R_0(1 + \alpha\Delta T)$, where α is the temperature coefficient of resistance.

Given. $R_0 = 5\,\Omega$ at $0\,°\text{C}$; $\alpha = 0.004\,\text{K}^{-1}$; $\Delta T = 100\,\text{K}$.

Step 1. Compute $\alpha\Delta T = 0.004 \times 100 = 0.4$.

Step 2. Compute the factor $(1 + \alpha\Delta T) = 1 + 0.4 = 1.4$.

Step 3. Compute $R_T = 5 \times 1.4 = 7\,\Omega$.

Answer: (B)

← Go back to Q17

Q18. Magnetic field around a long straight wire.

Solution

Concept. By Ampere's law, the magnetic field around an infinitely long straight current-carrying wire is $B = \frac{\mu_0 I}{2\pi r}$, where r is the perpendicular distance from the wire. The field circles the wire (right-hand rule).

Step 1. Of the options, only $\frac{\mu_0 I}{2\pi r}$ matches Ampere's law.

Common confusion. The formula for the field at the centre of a circular loop is $\mu_0 I/(2r)$ - WITHOUT the π. Don't confuse the two.

Answer: (B)

← Go back to Q18

Q19. Time period of AC.

Solution

Concept. For any periodic signal, period $T = 1/f$. For Indian mains AC at $50\,\text{Hz}$, one full cycle takes $1/50 = 0.02\,\text{s}$, or $20\,\text{ms}$.

Step 1. Substitute: $T = 1/50$.

Step 2. Compute: $T = 0.02\,\text{s}$.

Answer: (A)

← Go back to Q19

Q20. Balmer series spectral region.

Solution

Concept. The Balmer series of hydrogen corresponds to electronic transitions from higher levels ($n \geq 3$) DOWN to the second level ($n = 2$). The wavelengths range roughly from $656\,\text{nm}$ (H-alpha, red) down to the series limit at $364.6\,\text{nm}$ (violet/near-UV).

Step 1. Most of the Balmer series is in the visible region; the limit is just past violet, in the near-ultraviolet, but the BULK of the series and what makes it famous (the four prominent lines: red, cyan, blue, violet) is visible to the human eye.

Step 2. Of the options, "Visible" is the standard textbook answer for the Balmer-series region.

Answer: (B)

← Go back to Q20

Q21. Half-life from decay constant.

Solution

Concept. Radioactive decay obeys $N(t) = N_0 e^{-\lambda t}$. Setting $N(T_{1/2}) = N_0/2$ and taking logarithms gives $T_{1/2} = \ln 2/\lambda = 0.693/\lambda$.

Given. $\lambda = 0.0693\,\text{min}^{-1}$.

Step 1. Apply $T_{1/2} = 0.693/\lambda$.

Step 2. Substitute: $T_{1/2} = 0.693/0.0693$.

Step 3. Compute: $T_{1/2} = 10\,\text{minutes}$.

Answer: (B)

← Go back to Q21

Q22. Acceleration in simple harmonic motion.

Solution

Concept. SHM is defined by the restoring-force equation $F = -kx$ (Hooke-type). Applying Newton's second law gives $a = F/m = -(k/m)x = -\omega^2 x$. So acceleration is directly proportional to displacement, but *oppositely directed*.

Step 1. Magnitude: $|a| = \omega^2|x|$ - increases linearly with displacement.

Step 2. Direction: always toward the equilibrium position (negative sign in $a = -\omega^2 x$).

Step 3. So acceleration is proportional to displacement (option B).

Answer: (B)

← Go back to Q22

Q23. Charge on a capacitor.

Solution

Concept. The defining relation for any capacitor: $Q = CV$, where C is capacitance and V is the voltage across the plates.

Given. $C = 10\,\mu\text{F} = 10 \times 10^{-6} = 10^{-5}\,\text{F}$; $V = 50\,\text{V}$.

Step 1. Substitute: $Q = 10^{-5} \times 50$.

Step 2. Compute: $Q = 5 \times 10^{-4}\,\text{C} = 0.0005\,\text{C}$.

Answer: (A)

← Go back to Q23

Q24. P-type semiconductor.

Solution

Concept. A pure (intrinsic) semiconductor like silicon has equal numbers of electrons and holes. Doping with a trivalent impurity (B, Al, Ga) creates extra "holes" - missing electrons in the bonding structure. These holes act as the majority charge carriers and conduct current.

Step 1. P-type semiconductors have HOLES as majority carriers. N-type (doped with pentavalent impurities) have ELECTRONS as majority carriers.

Step 2. So the answer is P-type.

Answer: (B)

← Go back to Q24

Q25. SI unit of magnetic flux.

Solution

Concept. Magnetic flux is defined as $\Phi_B = \int \vec{B} \cdot d\vec{A}$. In SI units: $[\Phi_B] = \mathrm{T} \cdot \mathrm{m}^2$, which is given a special name: the *weber* (Wb), after Wilhelm Weber.

Step 1. Compare the options. Tesla is the unit of field B. Henry is the unit of inductance. Ampere is the unit of current. Only weber matches flux.

Answer: (B)

← Go back to Q25

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	A	4	B	5	B
6	B	7	C	8	B	9	A	10	B
11	B	12	B	13	B	14	B	15	B
16	B	17	B	18	B	19	A	20	B
21	B	22	B	23	A	24	B	25	B