PhysicsByAaryan

CSIR NET · GATE · JEST · BARC – Physics

GATE Physics 2020 — Full Question Paper

Previous Year Questions with Official Answer Key

Inside this PDF

- Every GATE Physics (PH) 2020 question, in order
- Marking scheme + question type (MCQ/MSQ/NAT) on every question
- Subject & topic classification per question
- Official answer key at the end

65 Questions with answer key

Questions taken from official GATE Physics (PH) papers conducted by IITs / IISc.
Compiled by PhysicsByAaryan for free use by aspirants. Answer key at the end of this PDF.

Q1. [Marks: 1 | MCQ] General Aptitude · English

Gate 2020	MCQ	1M

He is known for his unscrupulous ways. He always sheds ___ tears to deceive people.

(A) fox's

(B) crocodile's

(C) crocodile

Q2. [Marks: 1 | MCQ] General Aptitude · English

Gate 2020	MCQ	1M

Jofra Archer, the England fast bowler, is ___ than accurate.

(A) more fast

(B) faster

(C) less fast

(D) more faster

Q3. [Marks: 1 | MCQ] General Aptitude · English

Gate 2020	MCQ	1M

Select the word that fits the analogy:

Build : Building :: Grow : ___

(A) Grown

(B) Grew

(C) Growth

(D) Growed

Q4. [Marks: 1 | MCQ] General Aptitude · English

Gate 2020	MCQ	1M

I do not think you know the case well enough to have opinions. Having said that, I agree with your other point.

What does the phrase "having said that" mean in the given text?

(A) as opposed to what I have said

(B) despite what I have said

(C) in addition to what I have said

(D) contrary to what I have said

Q5. [Marks: 1 | MCQ] General Aptitude · Mathematical Analysis

Gate 2020	MCQ	1M

Define $[x]$ as the greatest integer less than or equal to x, for each $x \in (-\infty, \infty)$. If $y = [x]$, then area under y for $x \in [1,4]$ is ___ .

(A) 1

(B) 3

(C) 4

(D) 6

Q6. [Marks: 2 | MCQ] General Aptitude · Reasoning

Gate 2020	MCQ	2 M

Crowd funding deals with mobilisation of funds for a project from a large number of people, who would be willing to invest smaller amounts through web-based platforms in the project.

Based on the above paragraph, which of the following is correct about crowd funding?

(A) Funds raised through unwilling contributions on web-based platforms.

(B) Funds raised through large contributions on web-based platforms.

(C) Funds raised through coerced contributions on web-based platforms.

(D) Funds raised through voluntary contributions on web-based platforms.

Q7. [Marks: 2 | MCQ] General Aptitude · Reasoning

Gate 2020	MCQ	2 M

P, Q, R and S are to be uniquely coded using α and β. If P is coded as α and Q as $\alpha\beta$, then R and S , respectively, can be coded as ___ .

(A) $\beta\alpha$ and $\alpha\beta$

(B) $\beta\beta$ and $\alpha\alpha$

(C) $\alpha\beta$ and $\beta\beta$

(D) $\beta\alpha$ and $\beta\beta$

Q8. [Marks: 2 | MCQ] General Aptitude · Mathematical Analysis

Gate 2020	MCQ	2 M

The sum of the first n terms in the sequence 8,88,888,8888, ... is ___ .

(A) $\frac{81}{80}(10^n - 1) + \frac{9}{8}n$

(B) $\frac{81}{80}(10^n - 1) - \frac{9}{8}n$

(C) $\frac{80}{81}(10^n - 1) + \frac{8}{9}n$

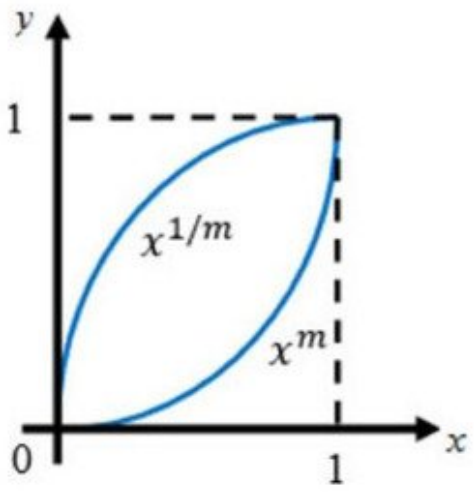
(D) $\frac{80}{81}(10^n - 1) - \frac{8}{9}n$

Q9. [Marks: 2 | MCQ] General Aptitude · Mathematical Analysis

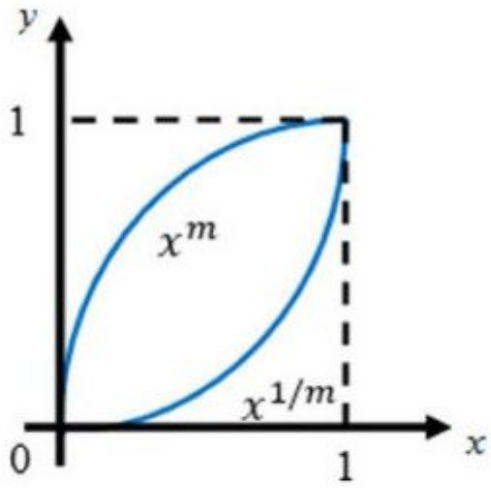
Gate 2020	MCQ	2 M

Select the graph that schematically represents BOTH $y = x^m$ and $y = x^{1/m}$ properly in the interval $0 \leq x \leq 1$, for integer values of m, where $m > 1$.

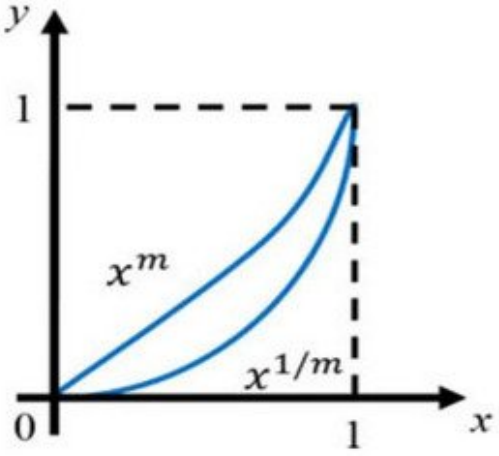
(A)



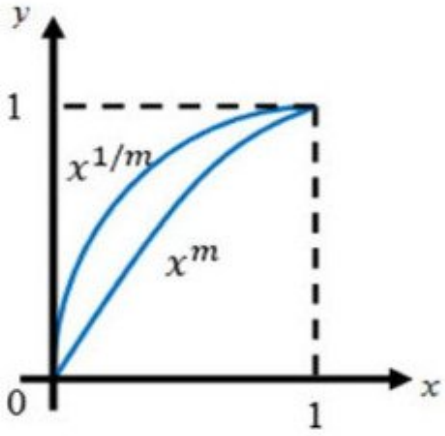
(B)



(C)



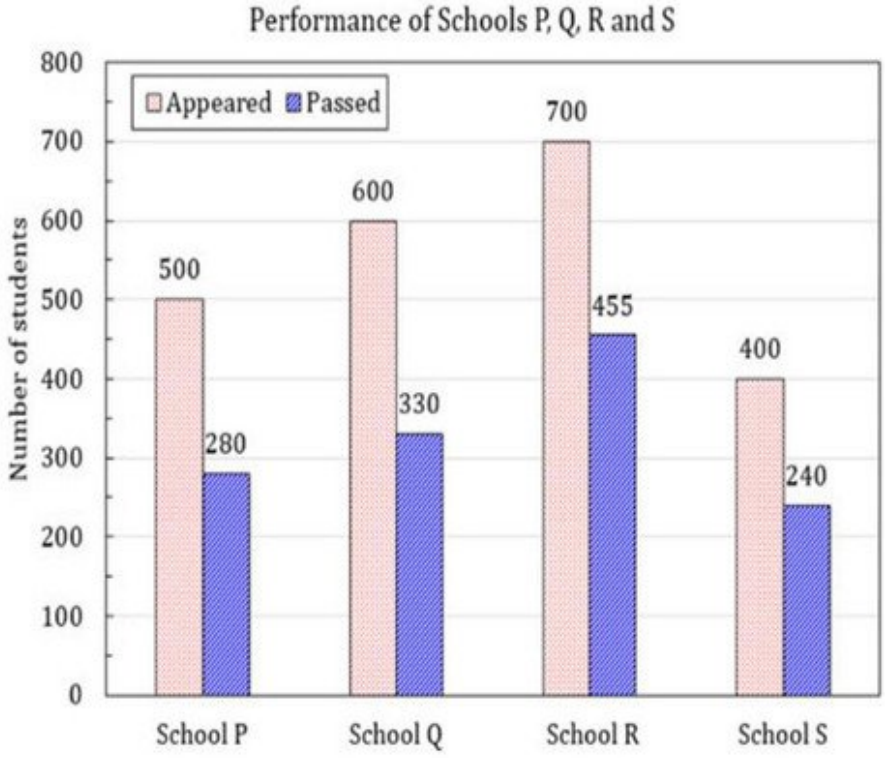
(D)



Q10. [Marks: 2 | MCQ] General Aptitude · Data Analysis

Gate 2020	MCQ	2 M

The bar graph shows the data of the students who appeared and passed in an examination for four schools P, Q, R and S. The average of success rates (in percentage) of these four schools is ___ .



(A) 58.5%

(B) 58.8%

(C) 59.0%

(D) 59.3%

Q11. [Marks: 1 | MCQ] Mathematical Physics · Differential Equations

Gate 2020	MCQ	1 M

Which one of the following is a solution of $\frac{d^2u(x)}{dx^2} = k^2u(x)$, for k real?

(A) e^{-kx}

(B) $\sin kx$

(C) $\cos kx$

(D) $\sinh x$

Q12. [Marks: 1 | MCQ] Mathematical Physics · Matrices

Gate 2020	MCQ	1 M

A real, invertible 3×3 matrix M has eigenvalues $\lambda_i, (i = 1,2,3)$ and the corresponding eigenvectors are $|e_i\rangle, (i = 1,2,3)$ respectively. Which one of the following is correct?

(A) $M|e_i\rangle = \frac{1}{\lambda_i}|e_i\rangle$, for $i = 1,2,3$

(B) $M^{-1}|e_i\rangle = \frac{1}{\lambda_i}|e_i\rangle$, for $i = 1,2,3$

(C) $M^{-1}|e_i\rangle = \lambda_i|e_i\rangle$, for $i = 1,2,3$

(D) The eigenvalues of M and M^{-1} are not related.

Q13. [Marks: 1 | MCQ] Quantum Mechanics · Potential Well

Gate 2020	MCQ	1 M

A quantum particle is subjected to the potential

$$V(x) = \begin{cases} \infty, & x \leq -\frac{a}{2} \\ 0, & -\frac{a}{2} < x < \frac{a}{2} \\ \infty, & x \geq \frac{a}{2} \end{cases}$$

The ground state wave function of the particle is proportional to

(A) $\sin\left(\frac{\pi x}{2a}\right)$

(B) $\sin\left(\frac{\pi x}{a}\right)$

(C) $\cos\left(\frac{\pi x}{2a}\right)$

(D) $\cos\left(\frac{\pi x}{a}\right)$

Q14. [Marks: 1 | MCQ] Quantum Mechanics · Quantum Harmonic Oscillator

Gate 2020	MCQ	1 M

Let $\hat{a}$ and $\hat{a}^\dagger$, respectively denote the lowering and raising operators of a onedimensional simple harmonic oscillator. Let $|n\rangle$ be the energy eigenstate of the simple harmonic oscillator. Given that $|n\rangle$ is also an eigenstate of $\hat{a}^\dagger\hat{a}^\dagger\hat{a}\hat{a}$, the corresponding eigenvalue is

(A) $n(n-1)$

(B) $n(n+1)$

(C) $(n+1)^2$

(D) n^2

Q15. [Marks: 1 | MCQ] Electronics · Logic Gates

Gate 2020	MCQ	1 M

Which one of the following is a universal logic gate?

(A) AND

(B) NOT

(C) OR

(D) NAND

Q16. [Marks: 1 | MCQ] Electronics · Logic Gates

Gate 2020	MCQ	1 M

Which one of the following is the correct binary equivalent of the hexadecimal F6C?

(A) 011011111100

(B) 111101101100

(C) 110001101111

(D) 011011000111

Q17. [Marks: 1 | MCQ] Nuclear and Particle Physics · Shell Model

Gate 2020	MCQ	1 M

The total angular momentum j of the ground state of the $^{17}_{8}O$ nucleus is

(A) $\frac{1}{2}$

(B) 1

(C) $\frac{3}{2}$

(D) $\frac{5}{2}$

Q18. [Marks: 1 | MCQ] Nuclear and Particle Physics · Particle Physics

Gate 2020	MCQ	1 M

A particle X is produced in the process $\pi^+ + p \rightarrow K^+ + X$ via the strong interaction. If the quark content of the K^+ is $u\bar{s}$, the quark content of X is

(A) $c\bar{s}$

(B) uud

(C) uus

(D) $u\bar{d}$

Q19. [Marks: 1 | MCQ] Electromagnetism · Electrodynamics

Gate 2020	MCQ	1 M

A medium $(\varepsilon_r > 1, \mu_r = 1, \sigma > 0)$ is semi-transparent to an electromagnetic wave when

(A) Conduction current $\gg$ Displacement current

(B) Conduction current << Displacement current

(C) Conduction current = Displacement current

(D) Both Conduction current and Displacement current are zero

Q20. [Marks: 1 | MCQ] Classical Mechanics · Central Forces

Gate 2020	MCQ	1 M

A particle is moving in a central force field given by $\vec{F} = -\frac{k}{r^3}\hat{r}$, where $\hat{r}$ is the unit vector pointing away from the center of the field. The potential energy of the particle is given by

(A) $\frac{k}{r^2}$

(B) $\frac{k}{2r^2}$

(C) $-\frac{k}{r^2}$

(D) $-\frac{k}{2r^2}$

Q21. [Marks: 1 | MCQ] Statistical Mechanics · Quantum Statistical Mechanics

Gate 2020	MCQ	1 M

Choose the correct statement related to the Fermi energy (E_F) and the chemical potential (μ) of a metal.

(A) $\mu = E_F$ only at 0 K

(B) $\mu = E_F$ at finite temperature

(C) $\mu < E_F$ at 0 K

(D) $\mu > E_F$ at finite temperature

Q22. [Marks: 1 | MCQ] Atomic and Molecular Physics · Molecular Physics

Gate 2020	MCQ	1 M

Consider a diatomic molecule formed by identical atoms. If E_V and E_e represent the energy of the vibrational nuclear motion and electronic motion respectively, then in terms of the electronic mass m and nuclear mass M, $\frac{E_V}{E_e}$ is proportional to

(A) $\left(\frac{m}{M}\right)^{1/2}$

(B) $\frac{m}{M}$

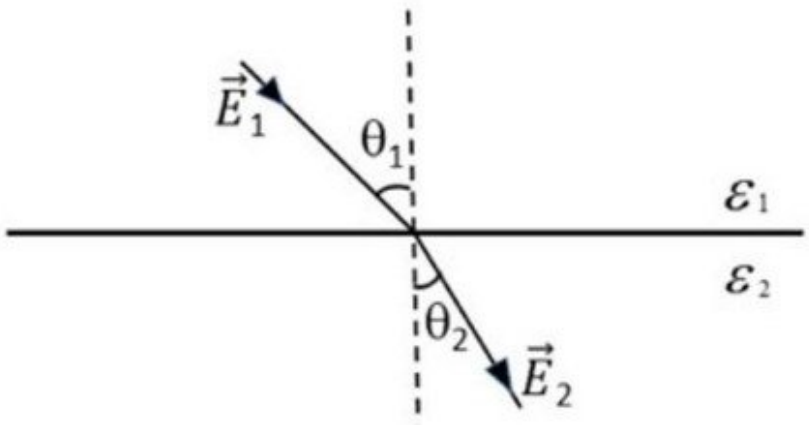
(C) $\left(\frac{m}{M}\right)^{3/2}$

(D) $\left(\frac{m}{M}\right)^{2}$

Q23. [Marks: 1 | MCQ] Electromagnetism · Electric field in matter

Gate 2020	MCQ	1 M

Which one of the following relations determines the manner in which the electric field lines are refracted across the interface between two dielectric media having dielectric constants ε_1 and ε_2 (see figure)?



(A) $\varepsilon_1 \sin\theta_1 = \varepsilon_2 \sin\theta_2$

(B) $\varepsilon_1 \cos\theta_1 = \varepsilon_2 \cos\theta_2$

(C) $\varepsilon_1 \tan\theta_1 = \varepsilon_2 \tan\theta_2$

(D) $\varepsilon_1 \cot\theta_1 = \varepsilon_2 \cot\theta_2$

Q24. [Marks: 1 | MCQ] Electromagnetism · Relativistic EMT

Gate 2020	MCQ	1 M

If $\vec{E}$ and $\vec{B}$ are the electric and magnetic fields respectively, then $\vec{E} \cdot \vec{B}$ is

(A) odd under parity and even under time reversal

(B) even under parity and odd under time reversal

(C) odd under parity and odd under time reversal

(D) even under parity and even under time reversal

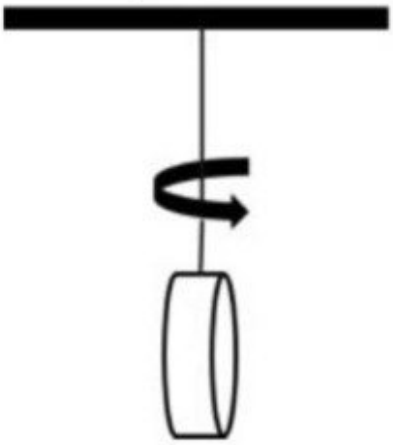
Q25. [Marks: 1 | MCQ] Thermodynamics · Kinetic theory of gases

Gate 2020	MCQ	1 M

A small disc is suspended by a fiber such that it is free to rotate about the fiber axis (see figure). For small angular deflections, the Hamiltonian for the disc is given by

$$H = \frac{p_\theta^2}{2I} + \frac{1}{2}\alpha\theta^2,$$

where I is the moment of inertia and α is the restoring torque per unit deflection. The disc is subjected to angular deflections (θ) due to thermal collisions from the surrounding gas at temperature T and p_θ is the momentum conjugate to θ. The average and the root-mean-square angular deflection, θ_{avg} and θ_{rms}, respectively are



(A) $\theta_{\text{avg}} = 0$ and $\theta_{\text{rms}} = \left(\frac{k_B T}{\alpha}\right)^{3/2}$

(B) $\theta_{\text{avg}} = 0$ and $\theta_{\text{rms}} = \left(\frac{k_B T}{\alpha}\right)^{1/2}$

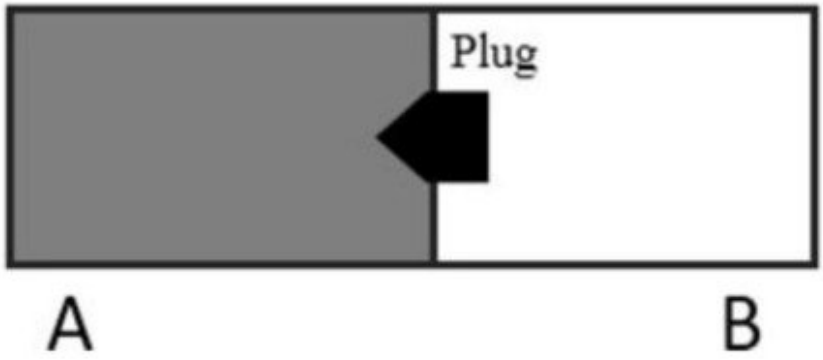
(C) $\theta_{\text{avg}} \neq 0$ and $\theta_{\text{rms}} = \left(\frac{k_B T}{\alpha}\right)^{1/2}$

$\theta_{\text{avg}} \neq 0$ and $\theta_{\text{rms}} = \left(\frac{k_B T}{\alpha}\right)^{3/2}$

Q26. [Marks: 1 | MCQ] Thermodynamics · Laws of thermodynamics

Gate 2020	MCQ	1 M

As shown in the figure, an ideal gas is confined to chamber A of an insulated container, with vacuum in chamber B. When the plug in the wall separating the chambers A and B is removed, the gas fills both the chambers. Which one of the following statements is true?



(A) The temperature of the gas remains unchanged

(B) Internal energy of the gas decreases

(C) Temperature of the gas decreases as it expands to fill the space in chamber B

(D) Internal energy of the gas increases as its atoms have more space to move around

Q27. [Marks: 1 | NAT] Quantum Mechanics · Spin and Total Angular momentum

Gate 2020	NAT	1 M

Particle A with angular momentum $j = \frac{3}{2}$ decays into two particles B and C with angular momenta j_1 and j_2, respectively. If $\left|\frac{3}{2},\frac{3}{2}\right\rangle_A = \alpha|1,1\rangle_B \otimes \left|\frac{1}{2},\frac{1}{2}\right\rangle_C$, the value of α is ___ .

Q28. [Marks: 1 | NAT] Electromagnetism · Magnetism

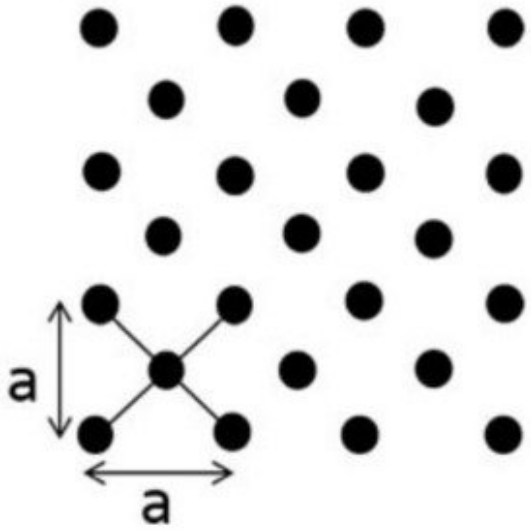
Gate 2020	NAT	1 M

Far from the Earth, the Earth's magnetic field can be approximated as due to a bar magnet of magnetic pole strength 4×10^{14}Am. Assume this magnetic field is generated by a current carrying loop encircling the magnetic equator. The current required to do so is about 4×10^{n} A, where n is an integer. The value of n is___ .
(Earth's circumference: 4×10^{7} m)

Q29. [Marks: 1 | NAT] Solid State Physics · Crystallography

Gate 2020	NAT	1 M

The number of distinct ways the primitive unit cell can be constructed for the two dimensional lattice as shown in the figure is ___ .



Q30. [Marks: 1 | NAT] Atomic and Molecular Physics · Effects in atomic physics

Gate 2020	NAT	1 M

A hydrogenic atom is subjected to a strong magnetic field. In the absence of spinorbit coupling, the number of doubly degenerate states created out of the d-level is___ .

Q31. [Marks: 1 | NAT] Nuclear and Particle Physics · Particle Physics

Gate 2020	NAT	1 M

A particle Y undergoes strong decay $Y \rightarrow \pi^- + \pi^-$.
The isospin of Y is ____.

Q32. [Marks: 1 | NAT] Mathematical Physics · Complex Analysis

Gate 2020	NAT	1 M

For a complex variable z and the contour c: $|z| = 1$ taken in the counter clockwise direction,

$$\frac{1}{2\pi i}\oint_c \left(z - \frac{2}{z} + \frac{3}{z^2}\right) dz =$$

Q33. [Marks: 1 | NAT] Classical Mechanics · Canonical Transformation and Poisson bracket

Gate 2020	NAT	1 M

Let p be the momentum conjugate to the generalized coordinate q. If the transformation

$$Q = \sqrt{2}q^m \cos p$$
$$P = \sqrt{2}q^m \sin p$$

is canonical, then $m =$ ____ .

Q34. [Marks: 1 | NAT] Electromagnetism · Electrostatics

Gate 2020	NAT	1 M

A conducting sphere of radius 1 m is placed in air. The maximum number of electrons that can be put on the sphere to avoid electrical breakdown is about 7×10^n, where n is an integer. The value of n is ____ .

Assume:

Breakdown electric field strength in air is

$$|\vec{E}| = 3 \times 10^6 \text{ V/m}$$

Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

Electron charge $e = 1.60 \times 10^{-19}$C

Q35. [Marks: 1 | NAT] Classical Mechanics · Lagrangian and Hamiltonian

Gate 2020	NAT	1 M

If a particle is moving along a sinusoidal curve, the number of degrees of freedom of the particle is ____.

Q36. [Marks: 2 | MCQ] Mathematical Physics · Matrices

Gate 2020	MCQ	2 M

The product of eigenvalues of $\begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix}$ is

(A) -1

(B) 1

(C) 0

(D) 2

Q37. [Marks: 2 | MCQ] Quantum Mechanics · Basics Quantum Mechanics

Gate 2020	MCQ	2 M

Let $|e_1\rangle \equiv \begin{pmatrix}1\\0\\0\end{pmatrix}, |e_2\rangle \equiv \begin{pmatrix}1\\1\\0\end{pmatrix}$ and $|e_3\rangle \equiv \begin{pmatrix}1\\1\\1\end{pmatrix}$. Let $S = \{|e_1\rangle, |e_2\rangle, |e_3\rangle\}$. Let $\mathbb{R}^3$ denote the three-dimensional real vector space. Which one of the following is correct?

(A) S is an orthonormal set

(B) S is a linearly dependent set

(C) S is a basis for $\mathbb{R}^3$

(D) $\sum_{i=1}^{3} |e_i\rangle\langle e_i| = \begin{pmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{pmatrix}$

Q38. [Marks: 2 | MCQ] Quantum Mechanics · Spin and Total Angular momentum

Gate 2020	MCQ	2 M

$\hat{S}_x$ denotes the spin operator defined as $\hat{S}_x = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$. Which one of the following is correct?

(A) The eigenstates of spin operator $\hat{S}_x$ are $|\uparrow\rangle_x \equiv \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $|\downarrow\rangle_x \equiv \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

(B) The eigenstates of spin operator $\hat{S}_x$ are $|\uparrow\rangle_x \equiv \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ -1 \end{pmatrix}$ and $|\uparrow\rangle_x \equiv \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ 1 \end{pmatrix}$

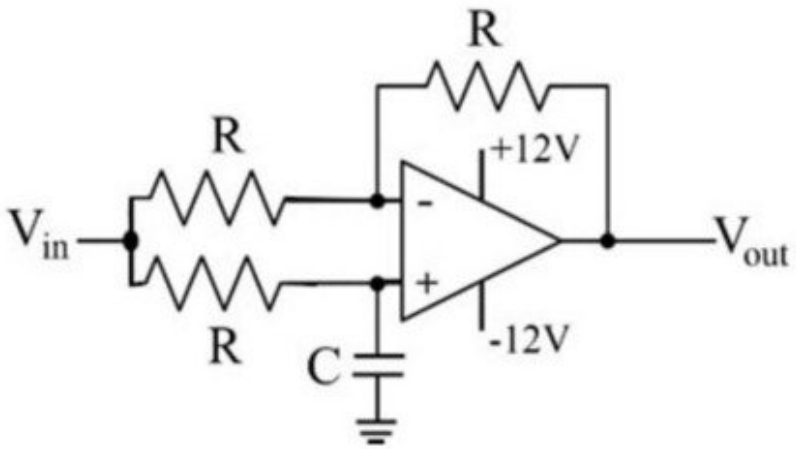
(C) In the spin state $\frac{1}{2}\begin{pmatrix} 1 \\ \sqrt{3} \end{pmatrix}$, upon the measurement of $\hat{S}_x$, the probability for obtaining $|\uparrow\rangle_x$ is $\frac{1}{4}$

(D) In the spin state $\frac{1}{2}\begin{pmatrix} 1 \\ \sqrt{3} \end{pmatrix}$, upon the measurement of $\hat{S}_x$, the probability for obtaining $|\uparrow\rangle_x$ is $\frac{2+\sqrt{3}}{4}$.

Q39. [Marks: 2 | MCQ] Electronics · OPAMP

Gate 2020	MCQ	2 M

The input voltage (V_{in}) to the circuit shown in the figure is $2\cos(100t)$V. The output voltage (V_{out}) is $2\cos\left(100t-\frac{\pi}{2}\right)$ V. If R = 1kΩ, the value of C(in μF) is



(A) 0.1

(B) 1

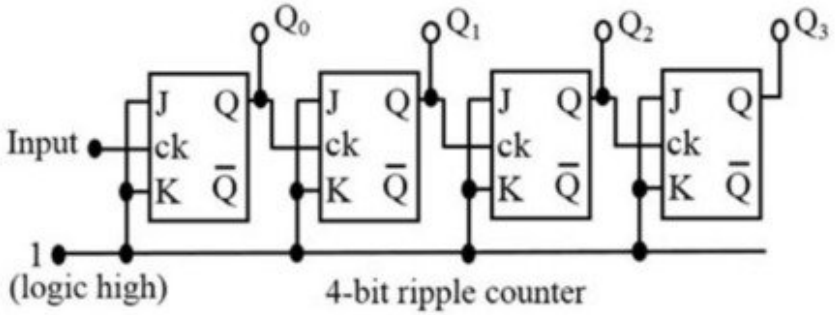
(C) 10

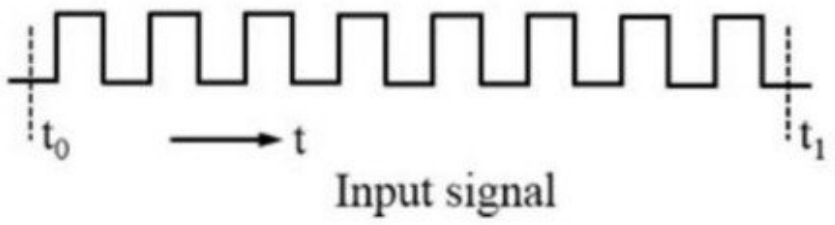
(D) 100

Q40. [Marks: 2 | MCQ] Electronics · Flip flops

Gate 2020	MCQ	2 M

Consider a 4-bit counter constructed out of four flip-flops. It is formed by connecting the J and K inputs to logic high and feeding the Q output to the clock input of the following flip-flop (see the figure). The input signal to the counter is a series of square pulses and the change of state is triggered by the falling edge. At time $t = t_0$ the outputs are in logic low state ($Q_0 = Q_1 = Q_2 = Q_3 = 0$). Then at $t = t_1$, the logic state of the outputs is





Input signal

(A) $Q_0 = 1, Q_1 = 0, Q_2 = 0$ and $Q_3 = 0$

(B) $Q_0 = 0, Q_1 = 0, Q_2 = 0$ and $Q_3 = 1$

(C) $Q_0 = 1, Q_1 = 0, Q_2 = 1$ and $Q_3 = 0$

(D) $Q_0 = 0, Q_1 = 1, Q_2 = 1$ and $Q_3 = 1$

Q41. [Marks: 2 | MCQ] Classical Mechanics · Lagrangian and Hamiltonian

Gate 2020	MCQ	2 M

Consider the Lagrangian

$L = a\left(\frac{dx}{dt}\right)^2 + b\left(\frac{dy}{dt}\right)^2 + cxy$, where a, b and c are constants. If p_x and p_y are the momenta conjugate to the coordinates x and y respectively, then the Hamiltonian is

(A) $\frac{{p_x}^2}{4a} + \frac{{p_y}^2}{4b} - cxy$

(B) $\frac{{p_x}^2}{2a} + \frac{{p_y}^2}{2b} - cxy$

(C) $\frac{{p_x}^2}{2a} + \frac{{p_y}^2}{2b} + cxy$

(D) $\frac{{p_x}^2}{a} + \frac{{p_y}^2}{b} + cxy$

Q42. [Marks: 2 | MCQ] Mathematical Physics · Matrices

Gate 2020	MCQ	2 M

Which one of the following matrices does NOT represent a proper rotation in a plane?

(A) $\begin{pmatrix} -\sin\theta & \cos\theta \\ -\cos\theta & -\sin\theta \end{pmatrix}$

(B) $\begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix}$

(C) $\begin{pmatrix} \sin\theta & \cos\theta \\ -\cos\theta & \sin\theta \end{pmatrix}$

(D) $\begin{pmatrix} -\sin\theta & \cos\theta \\ -\cos\theta & \sin\theta \end{pmatrix}$

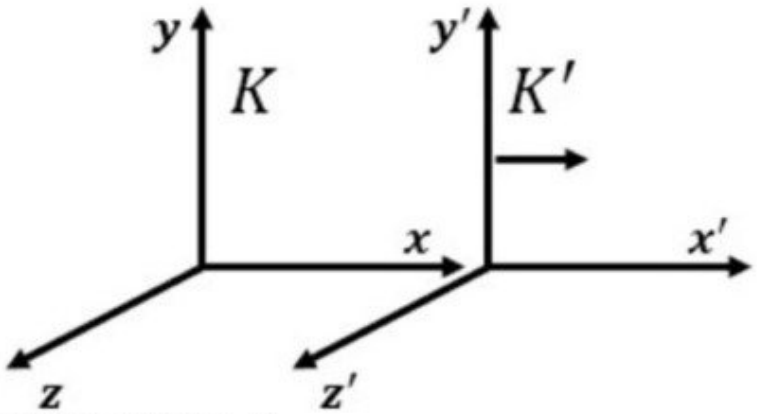
Q43. [Marks: 2 | MCQ] Electromagnetism · Relativistic EMT

Gate 2020	MCQ	2 M

A uniform magnetic field $\vec{B} = B_0\hat{y}$ exists in an inertial frame K. A perfect conducting sphere moves with a constant velocity $\vec{v} = v_0\hat{x}$ with respect to this inertial frame. The rest frame of the sphere is K' (see figure). The electric and magnetic fields in K and K' are related as

$$\left.\begin{aligned} \vec{E}'_{\parallel} &= \vec{E}_{\parallel} \quad \vec{E}'_{\perp} = \gamma\left(\vec{E}_{\perp} + \vec{v}\times\vec{B}\right) \\ \vec{B}'_{\parallel} &= \vec{B}_{\parallel} \quad \vec{B}'_{\perp} = \gamma\left(\vec{B}_{\perp} - \frac{\vec{v}}{c^2}\times\vec{E}\right) \end{aligned}\right\}, \gamma = \frac{1}{\sqrt{1-(v/c)^2}}$$

The induced surface charge density on the sphere (to the lowest order in v/c) in the frame K' is



(A) maximum along z'

(B) maximum along y'

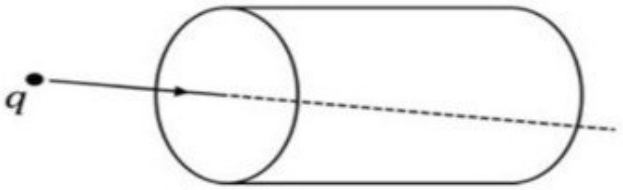
(C) maximum along x'

(D) uniform over the sphere

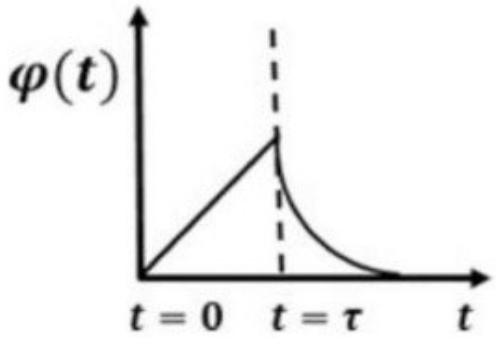
Q44. [Marks: 2 | MCQ] Electromagnetism · Electrodynamics

Gate 2020	MCQ	2 M

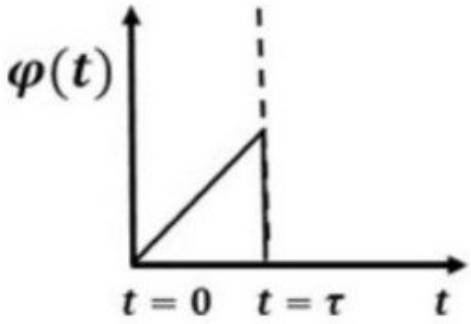
A charge q moving with uniform speed enters a cylindrical region in free space at $t = 0$ and exits the region at $t = \tau$ (see figure). Which one of the following options best describes the time dependence of the total electric flux $\varphi(t)$, through the entire surface of the cylinder?



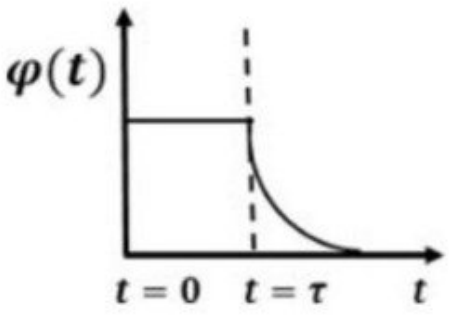
(A)



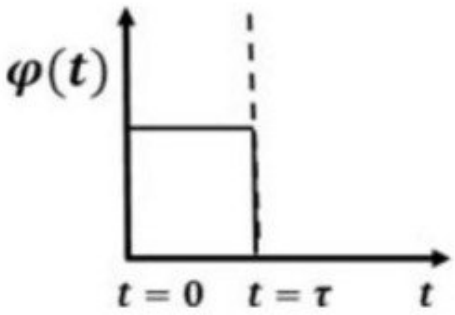
(B)



(C)



(D)



Q45. [Marks: 2 | MCQ] Solid State Physics · Free electron model

Gate 2020	MCQ	2 M

Consider a one-dimensional non-magnetic crystal with one atom per unit cell. Assume that the valence electrons (i) do not interact with each other and (ii) interact weakly with the ions. If n is the number of valence electrons per unit cell, then at 0 K,

(A) the crystal is metallic for any value of n

(B) the crystal is non-metallic for any value of n

(C) the crystal is metallic for even values of n

(D) the crystal is metallic for odd values of n

Q46. [Marks: 2 | MCQ] Nuclear and Particle Physics · Liquid Drop Model

Gate 2020	MCQ	2 M

According to the Fermi gas model of the nucleus, the nucleons move in a spherical volume of radius $R \left(= R_0 A^{\frac{1}{3}}\right.$, where A is the mass number and R_0 is an empirical constant with the dimensions of length). The Fermi energy of the nucleus E_F is proportional to

(A) R_0^2

(B) $\frac{1}{R_0}$

(C) $\frac{1}{R_0^2}$

(D) $\frac{1}{R_0^3}$

Q47. [Marks: 2 | MCQ] Solid State Physics · Lattice vibration

Gate 2020	MCQ	2 M

Consider a two dimensional crystal with 3 atoms in the basis. The number of allowed optical branches (n) and acoustic branches (m) due to the lattice vibrations are

(A) $(n, m) = (2,4)$

(B) $(n, m) = (3,3)$

(C) $(n, m) = (4,2)$

(D) $(n, m) = (1,5)$

Q48. [Marks: 2 | MCQ] Statistical Mechanics · Microcanonical ensemble

Gate 2020	MCQ	2 M

The internal energy U of a system is given by $U(S,V) = \lambda V^{-2/3} S^2$, where λ is a constant of appropriate dimensions; V and S denote the volume and entropy, respectively. Which one of the following gives the correct equation of state of the system?

(A) $\frac{PV^{1/3}}{T^2} = \text{constant}$

(B) $\frac{PV}{T^{1/3}} = \text{constant}$

(C) $\frac{P}{V^{1/3}T} = \text{constant}$

(D) $\frac{PV^{2/3}}{T} = \text{constant}$

Q49. [Marks: 2 | MCQ] Classical Mechanics · Small Oscillations

Gate 2020	MCQ	2 M

The potential energy of a particle of mass m is given by

$U(x) = a\sin(k^2x - \pi/2), a > 0, k^2 > 0.$

The angular frequency of small oscillations of the particle about $x = 0$ is

(A) $k^2\sqrt{\frac{2a}{m}}$

(B) $k^2\sqrt{\frac{a}{m}}$

(C) $k^2\sqrt{\frac{a}{2m}}$

(D) $2k^2\sqrt{\frac{a}{m}}$

Q50. [Marks: 2 | NAT] Quantum Mechanics · Orbital angular momentum and hydrogen atom

Gate 2020	NAT	2 M

The radial wave function of a particle in a central potential is given by $R(r) = A\frac{r}{a}\exp\left(-\frac{r}{2a}\right)$, where A is the normalization constant and a is positive constant of suitable dimensions. If γa is the most probable distance of the particle from the force center, the value of γ is ___ .

Q51. [Marks: 2 | NAT] Quantum Mechanics · Potential Well

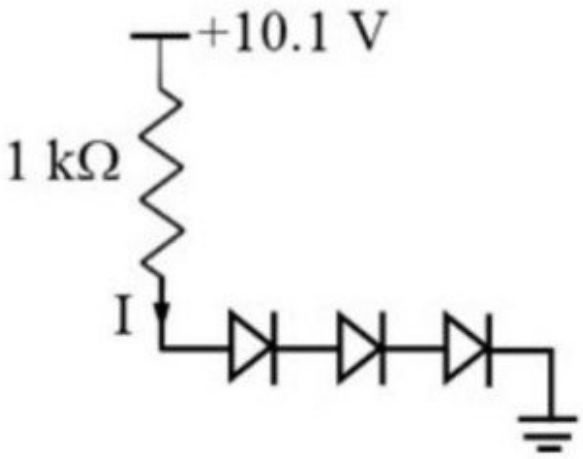
Gate 2020	NAT	2 M

A free particle of mass M is located in a three-dimensional cubic potential well with impenetrable walls. The degeneracy of the fifth excited state of the particle is___ .

Q52. [Marks: 2 | NAT] Electronics · Diodes

Gate 2020	NAT	2 M

Consider the circuit given in the figure. Let the forward voltage drop across each diode be 0.7 V . The current I (in mA) through the resistor is ___ .



Q53. [Marks: 2 | NAT] Mathematical Physics · Tensors

Gate 2020	NAT	2 M

Let u^{μ} denote the 4 -velocity of a relativistic particle whose square $u^{\mu}u_{\mu} = 1$. If $\varepsilon_{\mu\nu\rho\sigma}$ is the Levi-Civita tensor then the value of $\varepsilon_{\mu\nu\rho\sigma}u^{\mu}u^{\nu}u^{\rho}u^{\sigma}$ is ___ .

Q54. [Marks: 2 | NAT] Solid State Physics · Xray diffraction

Gate 2020	NAT	2 M

Consider a simple cubic monoatomic Bravais lattice which has a basis with vectors $\overrightarrow{r_1} = 0, \overrightarrow{r_2} = \frac{a}{4}(\hat{x} + \hat{y} + \hat{z})$, a is the lattice parameter. The Bragg reflection is observed due to the change in the wave vector between the incident and the scattered beam as given by $\vec{K} = n_1\vec{G}_1 + n_2\vec{G}_2 + n_3\vec{G}_3$, where $\vec{G}_1, \vec{G}_2$, and $\vec{G}_3$ are primitive reciprocal lattice vectors. For $n_1 = 3, n_2 = 3$ and $n_3 = 2$, the geometrical structure factor is ___ .

Q55. [Marks: 2 | NAT] Electromagnetism · EM Waves

Gate 2020	NAT	2 M

A plane electromagnetic wave of wavelength λ is incident on a circular loop of conducting wire. The loop radius is $a(a \ll \lambda)$. The angle (in degrees), made by the Poynting vector with the normal to the plane of the loop to generate a maximum induced electrical signal, is ___ .

Q56. [Marks: 2 | NAT] Quantum Mechanics · Orbital angular momentum and hydrogen atom

Gate 2020	NAT	2 M

An electron in a hydrogen atom is in the state $n = 3, l = 2, m = -2$. Let $\hat{L}_y$ denote the y-component of the orbital angular momentum operator. If $\left(\Delta \hat{L}_y\right)^2 = \alpha \hbar^2$, the value of α is ___ .

Q57. [Marks: 2 | NAT] Electromagnetism · Electrodynamics

Gate 2020	NAT	2 M

A sinusoidal voltage of the form $V(t) = V_0 \cos(\omega t)$ is applied across a parallel plate capacitor placed in vacuum. Ignoring the edge effects, the induced emf within the region between the capacitor plates can be expressed as a power series in ω. The lowest non-vanishing exponent in ω is ___ .

Q58. [Marks: 2 | NAT] Mathematical Physics · Fourier and Laplace transform

Gate 2020	NAT	2 M

If $x = \sum_{k=1}^{\infty} a_k \sin kx$, for $-\pi \leq x \leq \pi$, the value of a_2 is ___ .

Q59. [Marks: 2 | NAT] Mathematical Physics · Fourier and Laplace transform

Gate 2020	NAT	2 M

Let $f_n(x) = \begin{cases} 0, & x < -\frac{1}{2n} \\ n, & -\frac{1}{2n} < x < \frac{1}{2n} \\ 0, & \frac{1}{2n} < x. \end{cases}$

The value of $\lim_{n\to\infty} \int_{-\infty}^{\infty} f_n(x) \sin x dx$ is ___ .

Q60. [Marks: 2 | NAT] Quantum Mechanics · Perturbation Theory

Gate 2020	NAT	2 M

Consider the Hamiltonian $\hat{H} = \hat{H}_0 + \hat{H}'$ where

$\hat{H}_0 = \begin{pmatrix} E & 0 & 0 \\ 0 & E & 0 \\ 0 & 0 & E \end{pmatrix}$ and $\hat{H}'$ is the time independent perturbation given by

$\hat{H}' = \begin{pmatrix} 0 & k & 0 \\ k & 0 & k \\ 0 & k & 0 \end{pmatrix}$, where $k > 0$. If, the maximum energy eigenvalue of $\hat{H}$ is 3 eV corresponding to $E = 2$eV, the value of k (rounded off to three decimal places) in eV is ___ .

Q61. [Marks: 2 | NAT] Atomic and Molecular Physics · Vector Model

Gate 2020	NAT	2 M

A hydrogen atom is in an orbital angular momentum state $|l, m = l\rangle$. If $\vec{L}$ lies on a cone which makes a half angle 30° with respect to the z-axis, the value of l is

Q62. [Marks: 2 | NAT] Nuclear and Particle Physics · Radioactivity

Gate 2020	NAT	2 M

In the center of mass frame, two protons each having energy 7000 GeV , collide to produce protons and anti-protons. The maximum number of anti-protons produced is ___ .
(Assume the proton mass to be $1\text{GeV}/c^2$)

Q63. [Marks: 2 | NAT] Statistical Mechanics · Canonical ensemble

Gate 2020	NAT	2 M

Consider a gas of hydrogen atoms in the atmosphere of the Sun where the temperature is 5800 K . If a sample from this atmosphere contains 6.023×10^{23} of hydrogen atoms in the ground state, the number of hydrogen atoms in the first excited state is approximately 8×10^{n}, where n is an integer. The value of n is____ .
(Boltzmann constant: $8.617 \times 10^{-5}\text{eV/K}$)

Q64. [Marks: 2 | NAT] Thermodynamics · Kinetic theory of gases

Gate 2020	NAT	2 M

For a gas of non-interacting particles, the probability that a particle has a speed v in the interval v to $v + dv$ is given by

$$f(v)dv = 4\pi v^2 dv \left(\frac{m}{2\pi k_B T}\right)^{3/2} e^{-mv^2/2k_B T}$$

If E is the energy of a particle, then the maximum in the corresponding energy distribution in units of $E/k_B T$ occurs at ___
(rounded off to one decimal place).

Q65. [Marks: 2 | NAT] Statistical Mechanics · Quantum Statistical Mechanics

Gate 2020	NAT	2 M

The Planck's energy density distribution is given by $u(\omega) = \frac{\hbar\omega^3}{\pi^2 c^3 (e^{\hbar\omega/k_B T} - 1)}$. At long wavelengths, the energy density of photons in thermal equilibrium with a cavity at temperature T varies as T^{α}, where α is ___.

Answer Key

65 questions · Subject & topic for quick revision · Official keys (IIT/IISc)

Q.No	Subject	Topic	Type	Marks	Answer
Q1	General Aptitude	English	MCQ	1	**C**
Q2	General Aptitude	English	MCQ	1	**A**
Q3	General Aptitude	English	MCQ	1	**C**
Q4	General Aptitude	English	MCQ	1	**B**
Q5	General Aptitude	Mathematical Analysis	MCQ	1	**D**
Q6	General Aptitude	Reasoning	MCQ	2	**D**
Q7	General Aptitude	Reasoning	MCQ	2	**D**
Q8	General Aptitude	Mathematical Analysis	MCQ	2	**D**
Q9	General Aptitude	Mathematical Analysis	MCQ	2	**A**
Q10	General Aptitude	Data Analysis	MCQ	2	**C**
Q11	Mathematical Physics	Differential Equations	MCQ	1	**A**
Q12	Mathematical Physics	Matrices	MCQ	1	**B**
Q13	Quantum Mechanics	Potential Well	MCQ	1	**D**
Q14	Quantum Mechanics	Quantum Harmonic Oscillator	MCQ	1	**A**
Q15	Electronics	Logic Gates	MCQ	1	**D**
Q16	Electronics	Logic Gates	MCQ	1	**B**
Q17	Nuclear and Particle Phy…	Shell Model	MCQ	1	**D**
Q18	Nuclear and Particle Phy…	Particle Physics	MCQ	1	**C**
Q19	Electromagnetism	Electrodynamics	MCQ	1	**B**
Q20	Classical Mechanics	Central Forces	MCQ	1	**D**
Q21	Statistical Mechanics	Quantum Statistical Mechanics	MCQ	1	**A**
Q22	Atomic and Molecular Ph…	Molecular Physics	MCQ	1	**A**
Q23	Electromagnetism	Electric field in matter	MCQ	1	**D**
Q24	Electromagnetism	Relativistic EMT	MCQ	1	**C**
Q25	Thermodynamics	Kinetic theory of gases	MCQ	1	**B**
Q26	Thermodynamics	Laws of thermodynamics	MCQ	1	**A**
Q27	Quantum Mechanics	Spin and Total Angular momentum	NAT	1	**1 to 1**
Q28	Electromagnetism	Magnetism	NAT	1	**7 to 7**
Q29	Solid State Physics	Crystallography	NAT	1	**5 to 5**
Q30	Atomic and Molecular Ph…	Effects in atomic physics	NAT	1	**3 to 3**
Q31	Nuclear and Particle Phy…	Particle Physics	NAT	1	**2 to 2**
Q32	Mathematical Physics	Complex Analysis	NAT	1	**-2 to -2**
Q33	Classical Mechanics	Canonical Transformation and Poiss…	NAT	1	**0.5 to 0.5**
Q34	Electromagnetism	Electrostatics	NAT	1	**14 to 15**
Q35	Classical Mechanics	Lagrangian and Hamiltonian	NAT	1	**1 to 1**
Q36	Mathematical Physics	Matrices	MCQ	2	**A**

Answer Key

65 questions · Subject & topic for quick revision · Official keys (IIT/IISc)

Q.No	Subject	Topic	Type	Marks	Answer
Q37	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	**C**
Q38	Quantum Mechanics	Spin and Total Angular momentum	MCQ	2	**D**
Q39	Electronics	OPAMP	MCQ	2	**C**
Q40	Electronics	Flip flops	MCQ	2	**B**
Q41	Classical Mechanics	Lagrangian and Hamiltonian	MCQ	2	**A**
Q42	Mathematical Physics	Matrices	MCQ	2	**D**
Q43	Electromagnetism	Relativistic EMT	MCQ	2	**A**
Q44	Electromagnetism	Electrodynamics	MCQ	2	**D**
Q45	Solid State Physics	Free electron model	MCQ	2	**D**
Q46	Nuclear and Particle Phy…	Liquid Drop Model	MCQ	2	**C**
Q47	Solid State Physics	Lattice vibration	MCQ	2	**C**
Q48	Statistical Mechanics	Microcanonical ensemble	MCQ	2	**A**
Q49	Classical Mechanics	Small Oscillations	MCQ	2	**B**
Q50	Quantum Mechanics	Orbital angular momentum and hydr…	NAT	2	**4 to 4**
Q51	Quantum Mechanics	Potential Well	NAT	2	**6 to 6**
Q52	Electronics	Diodes	NAT	2	**8 to 8**
Q53	Mathematical Physics	Tensors	NAT	2	**0 to 0**
Q54	Solid State Physics	Xray diffraction	NAT	2	**2 to 2**
Q55	Electromagnetism	EM Waves	NAT	2	**-270 to -270 or□ …**
Q56	Quantum Mechanics	Orbital angular momentum and hydr…	NAT	2	**1 to 1**
Q57	Electromagnetism	Electrodynamics	NAT	2	**2 to 2**
Q58	Mathematical Physics	Fourier and Laplace transform	NAT	2	**-1 to -1**
Q59	Mathematical Physics	Fourier and Laplace transform	NAT	2	**0 to 0**
Q60	Quantum Mechanics	Perturbation Theory	NAT	2	**0.706 to 0.708**
Q61	Atomic and Molecular Ph…	Vector Model	NAT	2	**3 to 3**
Q62	Nuclear and Particle Phy…	Radioactivity	NAT	2	**6999 to 6999**
Q63	Statistical Mechanics	Canonical ensemble	NAT	2	**14 to 15**
Q64	Thermodynamics	Kinetic theory of gases	NAT	2	**0.5 to 0.5**
Q65	Statistical Mechanics	Quantum Statistical Mechanics	NAT	2	**1 to 1**