

PhysicsByAaryan

CSIR NET · GATE · JEST · BARC – Physics

GATE Physics 2016 — Full Question Paper

Previous Year Questions with Official Answer Key

Inside this PDF

- Every GATE Physics (PH) 2016 question, in order
- Marking scheme + question type (MCQ/MSQ/NAT) on every question
- Subject & topic classification per question
- Official answer key at the end

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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 · Geometry

Gate 2016	MCQ	1 M
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The volume of a sphere of diameter 1 unit is ___ than the volume of a cube of side 1 unit.

- (A) least
- (B) less
- (C) lesser
- (D) low

Q2. [Marks: 1 | MCQ]

General Aptitude · English

Gate 2016	MCQ	1 M
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The unruly crowd demanded that the accused be ___ without trial.

- (A) hanged
- (B) hanging
- (C) hankering
- (D) hung

Q3. [Marks: 1 | MCQ]

General Aptitude · English

Gate 2016	MCQ	1 M
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Choose the statement(s) where the underlined word is used correctly:

- (i) A prone is a dried plum.
- (ii) He was lying prone on the floor.
- (iii) People who eat a lot of fat are prone to heart disease.

- (A) (i) and (iii) only
- (B) (iii) only
- (C) (i) and (ii) only
- (D) (ii) and (iii) only

Q4. [Marks: 1 | MCQ]

General Aptitude · Reasoning

Gate 2016	MCQ	1 M
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Fact: If it rains, then the field is wet.

Read the following statements:

- (i) It rains
- (ii) The field is not wet
- (iii) The field is wet
- (iv) It did not rain

Which one of the options given below is NOT logically possible, based on the given fact?

- (A) If (iii), then (iv).
- (B) If (i), then (iii).
- (C) If (i), then (ii).
- (D) If (ii), then (iv).

Q5. [Marks: 1 | MCQ]

General Aptitude · Geometry

Gate 2016	MCQ	1 M
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A window is made up of a square portion and an equilateral triangle portion above it. The base of the triangular portion coincides with the upper side of the square. If the perimeter of the window is 6 m , the area of the window in m^2 is ____ .

- (A) 1.43
- (B) 2.06
- (C) 2.68
- (D) 2.88

Q6. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2016	MCQ	2 M
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Students taking an exam are divided into two groups, **P** and **Q** such that each group has the same number of students. The performance of each of the students in a test was evaluated out of 200 marks. It was observed that the mean of group **P** was 105, while that of group **Q** was 85. The standard deviation of group **P** was 25, while that of group **Q** was 5. Assuming that the marks were distributed on a normal distribution, which of the following statements will have the highest probability of being TRUE?

- (A) No student in group **Q** scored less marks than any student in group **P**.
- (B) No student in group **P** scored less marks than any student in group **Q**.
- (C) Most students of group **Q** scored marks in a narrower range than students in group **P**.
- (D) The median of the marks of group **P** is 100.

Q7. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2016	MCQ	2 M
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A smart city integrates all modes of transport, uses clean energy and promotes sustainable use of resources. It also uses technology to ensure safety and security of the city, something which critics argue, will lead to a surveillance state.

Which of the following can be logically inferred from the above paragraph?

- (i) All smart cities encourage the formation of surveillance states.
 - (ii) Surveillance is an integral part of a smart city.
 - (iii) Sustainability and surveillance go hand in hand in a smart city.
 - (iv) There is a perception that smart cities promote surveillance.
- (A) (i) and (iv) only
(B) (ii) and (iii) only
(C) (iv) only
(D) (i) only

Q8. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2016	MCQ	2 M
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Find the missing sequence in the letter series.

B, FH, LNP, ____ .

- (A) SUWY
- (B) TUVW
- (C) TVXZ
- (D) TWXZ

Q9. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2016	MCQ	2 M
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The binary operation \square is defined as

$a \square b = ab + (a + b)$, where a and b are any two real numbers. The value of the identity element of this operation, defined as the number x such that

$a \square x = a$, for any a , is ____ .

- (A) 0
- (B) 1
- (C) 2
- (D) 10

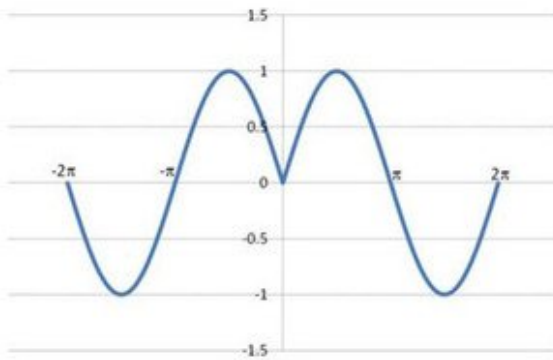
Q10. [Marks: 2 | MCQ]

General Aptitude · Mathematical Analysis

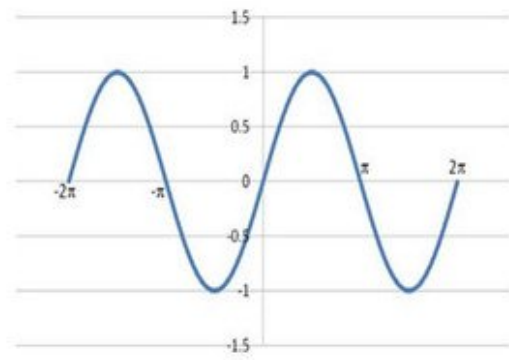
Gate 2016	MCQ	2 M
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Which of the following curves represents the function $y = \ln(|e^{[|\sin(|x|)]}|)$ for $|x| < 2\pi$? Here, x represents the abscissa and y represents the ordinate.

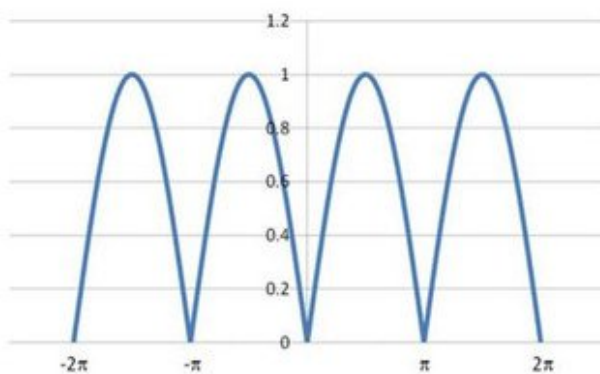
A)



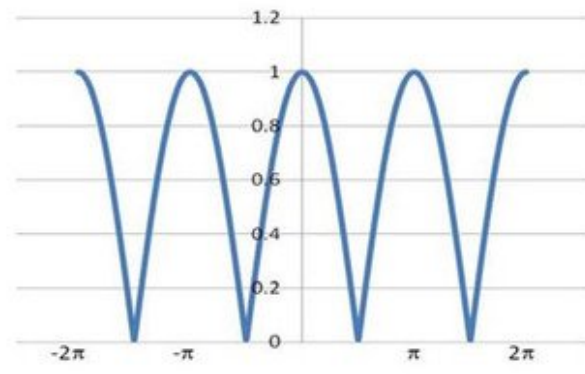
B)



C)



D)



Q11. [Marks: 1 | MCQ]

Mathematical Physics · Differential Equations

Gate 2016	MCQ	1 M
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Consider the linear differential equation $\frac{dy}{dx} = xy$. If $y = 2$ at $x = 0$, then the value of y at $x = 2$ is given by

- (A) e^{-2}
- (B) $2e^{-2}$
- (C) e^2
- (D) $2e^2$

Q12. [Marks: 1 | MCQ]

Electromagnetism · Magnetism

Gate 2016	MCQ	1 M
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Which of the following magnetic vector potentials gives rise to a uniform magnetic field $B_0 \hat{k}$?

- (A) $B_0 z \hat{k}$
- (B) $-B_0 x \hat{j}$
- (C) $\frac{B_0}{2} (-y \hat{i} + x \hat{j})$
- (D) $\frac{B_0}{2} (y \hat{i} + x \hat{j})$

Q13. [Marks: 1 | MCQ]

Atomic and Molecular Physics · ESR/EPR/NMR

Gate 2016	MCQ	1 M
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The molecule $^{17}\text{O}_2$ is

- (A) Raman active but not NMR (nuclear magnetic resonance) active.
- (B) Infrared active and Raman active but not NMR active.
- (C) Raman active and NMR active.
- (D) Only NMR active.

Q14. [Marks: 1 | NAT]

Atomic and Molecular Physics · Vector Model

Gate 2016	NAT	1 M
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There are four electrons in the $3d$ shell of an isolated atom. The total magnetic moment of the atom in units of Bohr magneton is ____ .

Q15. [Marks: 1 | MCQ]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2016	MCQ	1 M
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Which of the following transitions is NOT allowed in the case of an atom, according to the electric dipole radiation selection rule?

- (A) $2s - 1s$
- (B) $2p - 1s$
- (C) $2p - 2s$
- (D) $3d - 2p$

Q16. [Marks: 1 | MCQ]

Nuclear and Particle Physics · Particle Physics

Gate 2016	MCQ	1 M
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In the SU(3) quark model, the triplet of mesons (π^+, π^0, π^-) has

- (A) Isospin = 0, Strangeness = 0
- (B) Isospin = 1, Strangeness = 0
- (C) Isospin = 1/2, Strangeness = +1
- (D) Isospin = 1/2, Strangeness = -1

Q17. [Marks: 1 | NAT]

Electromagnetism · Magnetism

Gate 2016	NAT	1 M
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The magnitude of the magnetic dipole moment associated with a square shaped loop carrying a steady current I is m . If this loop is changed to a circular shape with the same current I passing through it, the magnetic dipole moment becomes $\frac{pm}{\pi}$. The value of p is ____ .

Q18. [Marks: 1 | NAT]

Statistical Mechanics · Quantum Statistical Mechanics

Gate 2016	NAT	1 M
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The total power emitted by a spherical black body of radius R at a temperature T is P_1 . Let P_2 be the total power emitted by another spherical black body of radius $R/2$ kept at temperature $2T$. The ratio, P_1/P_2 is ____ . (Give your answer upto two decimal places)

Q19. [Marks: 1 | NAT]

Statistical Mechanics · Microcanonical ensemble

Gate 2016	NAT	1 M
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The entropy S of a system of N spins, which may align either in the upward or in the downward direction, is given by

$S = -k_B N [p \ln p + (1 - p) \ln(1 - p)]$. Here k_B is the Boltzmann constant. The probability of alignment in the upward direction is p . The value of p , at which the entropy is maximum, is ____ (Give your answer upto one decimal place)

Q20. [Marks: 1 | MCQ]

Thermodynamics · Thermodynamic Potential

Gate 2016	MCQ	1 M
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For a system at constant temperature and volume, which of the following statements is correct at equilibrium?

- (A) The Helmholtz free energy attains a local minimum.
- (B) The Helmholtz free energy attains a local maximum.
- (C) The Gibbs free energy attains a local minimum.
- (D) The Gibbs free energy attains a local maximum.

Q21. [Marks: 1 | NAT]

Statistical Mechanics · Microcanonical ensemble

Gate 2016	NAT	1 M
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N atoms of an ideal gas are enclosed in a container of volume V . The volume of the container is changed to $4V$, while keeping the total energy constant. The change in the entropy of the gas, in units of $Nk_B \ln 2$, is ____, where k_B is the Boltzmann constant.

Q22. [Marks: 1 | MCQ]

Mathematical Physics · Complex Analysis

Gate 2016	MCQ	1 M
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Which of the following is an analytic function of z everywhere in the complex plane?

- (A) z^2
- (B) $(z')^2$
- (C) $|z|^2$
- (D) \sqrt{z}

Q23. [Marks: 1 | NAT]

Optics · Interference and Diffraction

Gate 2016	NAT	1 M
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In a Young's double slit experiment using light, the apparatus has two slits of unequal widths. When only slit-1 is open, the maximum observed intensity on the screen is $4I_0$. When only slit-2 is open, the maximum observed intensity is I_0 . When both the slits are open, an interference pattern appears on the screen. The ratio of the intensity of the principal maximum to that of the nearest minimum is ____ .

Q24. [Marks: 1 | MCQ]

Solid State Physics · Hall Effect

Gate 2016	MCQ	1 M
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Consider a metal which obeys the Sommerfeld model exactly. If E_F is the Fermi energy of the metal at $T = 0$ K and R_H is its Hall coefficient, which of the following statements is correct?

- (A) $R_H \propto E_F^{3/2}$
- (B) $R_H \propto E_F^{2/3}$
- (C) $R_H \propto E_F^{-3/2}$
- (D) R_H is independent of E_F

Q25. [Marks: 1 | MCQ]

Solid State Physics · Lattice vibration

Gate 2016	MCQ	1 M
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A one-dimensional linear chain of atoms contains two types of atoms of masses m_1 and m_2 (where $m_2 > m_1$), arranged alternately. The distance between successive atoms is the same. Assume that the harmonic approximation is valid. At the first Brillouin zone boundary, which of the following statements is correct?

- (A) The atoms of mass m_2 are at rest in the optical mode, while they vibrate in the acoustical mode.
- (B) The atoms of mass m_1 are at rest in the optical mode, while they vibrate in the acoustical mode.
- (C) Both types of atoms vibrate with equal amplitudes in the optical as well as in the acoustical modes.
- (D) Both types of atoms vibrate, but with unequal, non-zero amplitudes in the optical as well as in the acoustical modes.

Q26. [Marks: 1 | MCQ]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2016	MCQ	1 M
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Which of the following operators is Hermitian?

- (A) $\frac{d}{dx}$
- (B) $\frac{d^2}{dx^2}$
- (C) $i \frac{d^2}{dx^2}$
- (D) $\frac{d^3}{dx^3}$

Q27. [Marks: 1 | NAT]

Classical Mechanics · Special theory of relativity

Gate 2016	NAT	1 M
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The kinetic energy of a particle of rest mass m_0 is equal to its rest mass energy. Its momentum in units of m_0c , where c is the speed of light in vacuum, is ____ . (Give your answer upto two decimal places)

Q28. [Marks: 1 | NAT]

Solid State Physics · Semiconductor Physics

Gate 2016	NAT	1 M
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The number density of electrons in the conduction band of a semiconductor at a given temperature is $2 \times 10^{19} \text{ m}^{-3}$. Upon lightly doping this semiconductor with donor impurities, the number density of conduction electrons at the same temperature becomes $4 \times 10^{20} \text{ m}^{-3}$. The ratio of majority to minority charge carrier concentration is ____ .

Q29. [Marks: 1 | NAT]

Classical Mechanics · Small Oscillations

Gate 2016	NAT	1 M
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Two blocks are connected by a spring of spring constant k . One block has mass m and the other block has mass $2m$. If the ratio $k/m = 4 \text{ s}^{-2}$, the angular frequency of vibration ω of the two block spring system in s^{-1} is ____ . (Give your answer upto two decimal places)

Q30. [Marks: 1 | MCQ]

Classical Mechanics · Central Forces

Gate 2016	MCQ	1 M
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A particle moving under the influence of a central force $\vec{F}(\vec{r}) = -k\vec{r}$ (where \vec{r} is the position vector of the particle and k is a positive constant) has non-zero angular momentum. Which of the following curves is a possible orbit for this particle?

- (A) A straight line segment passing through the origin.
- (B) An ellipse with its center at the origin.
- (C) An ellipse with one of the foci at the origin.
- (D) A parabola with its vertex at the origin.

Q31. [Marks: 1 | MCQ]

Nuclear and Particle Physics · Radioactivity

Gate 2016	MCQ	1 M
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Consider the reaction ${}_{25}^{54}\text{Mn} + e^{-} \rightarrow {}_{24}^{54}\text{Cr} + X$. The particle X is

- (A) γ
- (B) ν_e
- (C) n
- (D) π^0

Q32. [Marks: 1 | MCQ]

Quantum Mechanics · Scattering Theory

Gate 2016	MCQ	1 M
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The scattering of particles by a potential can be analyzed by Born approximation. In particular, if the scattered wave is replaced by an appropriate plane wave, the corresponding Born approximation is known as the first Born approximation. Such an approximation is valid for

- (A) large incident energies and weak scattering potentials.
- (B) large incident energies and strong scattering potentials.
- (C) small incident energies and weak scattering potentials.
- (D) small incident energies and strong scattering potentials.

Q33. [Marks: 1 | NAT]

Quantum Mechanics · Scattering Theory

Gate 2016	NAT	1 M
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Consider an elastic scattering of particles in $l = 0$ states. If the corresponding phase shift δ_0 is 90° and the magnitude of the incident wave vector is equal to $\sqrt{2\pi} \text{fm}^{-1}$ then the total scattering cross section in units of fm^2 is ____ .

Q34. [Marks: 1 | NAT]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2016	NAT	1 M
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A hydrogen atom is in its ground state. In the presence of a uniform electric field $\vec{E} = E_0 \hat{z}$, the leading order change in its energy is proportional to $(E_0)^n$. The value of the exponent n is ____ .

Q35. [Marks: 1 | MCQ]

Solid State Physics · Magnetic properties of solids

Gate 2016	MCQ	1 M
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A solid material is found to have a temperature independent magnetic susceptibility, $\chi = C$. Which of the following statements is correct?

- (A) If C is positive, the material is a diamagnet.
- (B) If C is positive, the material is a ferromagnet.
- (C) If C is negative, the material could be a type I superconductor.
- (D) If C is positive, the material could be a type I superconductor.

Q36. [Marks: 2 | MCQ]

Electromagnetism · Electric field in matter

Gate 2016	MCQ	2 M
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An infinite, conducting slab kept in a horizontal plane carries a uniform charge density σ . Another infinite slab of thickness t , made of a linear dielectric material of dielectric constant k , is kept above the conducting slab. The bound charge density on the upper surface of the dielectric slab is

- (A) $\frac{\sigma}{2k}$
(B) $\frac{\sigma}{k}$
(C) $\frac{\sigma(k-2)}{2k}$
(D) $\frac{\sigma(k-1)}{k}$

Q37. [Marks: 2 | NAT]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2016	NAT	2 M
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The number of spectroscopic terms resulting from the $L \cdot S$ coupling of a $3p$ electron and a $3d$ electron is ____ .

Q38. [Marks: 2 | MCQ]

Nuclear and Particle Physics · Nuclear Force, deuteron problem and scatteri

Gate 2016	MCQ	2 M
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Which of the following statements is NOT correct?

- (A) A deuteron can be disintegrated by irradiating it with gamma rays of energy 4 MeV .
- (B) A deuteron has no excited states.
- (C) A deuteron has no electric quadrupole moment.
- (D) The $^1 S_0$ state of deuteron cannot be formed.

Q39. [Marks: 2 | MCQ]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2016	MCQ	2 M
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If \vec{s}_1 and \vec{s}_2 are the spin operators of the two electrons of a He atom, the value of $\langle \vec{s}_1 \cdot \vec{s}_2 \rangle$ for the ground state is

- (A) $-\frac{3}{2} \hbar^2$
- (B) $-\frac{3}{4} \hbar^2$
- (C) 0
- (D) $\frac{1}{4} \hbar^2$

Q40. [Marks: 2 | NAT]

Quantum Mechanics · Potential Well

Gate 2016	NAT	2 M
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A two-dimensional square rigid box of side L contains six non-interacting electrons at $T = 0$ K. The mass of the electron is m . The ground state energy of the system of electrons, in units of $\frac{\pi^2 \hbar^2}{2mL^2}$ is ____ .

Q41. [Marks: 2 | NAT]

Nuclear and Particle Physics · Particle detector and accelerator

Gate 2016	NAT	2 M
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An alpha particle is accelerated in a cyclotron. It leaves the cyclotron with a kinetic energy of 16 MeV . The potential difference between the D electrodes is 50 kilovolts. The number of revolutions the alpha particle makes in its spiral path before it leaves the cyclotron is ____ .

Q42. [Marks: 2 | MCQ]

Mathematical Physics · Tensors

Gate 2016	MCQ	2 M
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Let V_i be the i^{th} component of a vector field \vec{V} , which has zero divergence. If $\partial_j \equiv \partial/\partial x_j$, the expression for $\epsilon_{ijk}\epsilon_{lmk}\partial_j\partial_l V_m$ is equal to

- (A) $-\partial_j\partial_k V_i$
 (B) $\partial_j\partial_k V_i$
 (C) $\partial_j^2 V_i$
 (D) $-\partial_j^2 V_i$

Q43. [Marks: 2 | MCQ]

Mathematical Physics · Vector Analysis

Gate 2016	MCQ	2 M
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The direction of $\vec{\nabla}f$ for a scalar field

$f(x, y, z) = \frac{1}{2}x^2 - xy + \frac{1}{2}z^2$ at the point $P(1,1,2)$ is

- (A) $\frac{(-\hat{j}-2\hat{k})}{\sqrt{5}}$
 (B) $\frac{(-\hat{j}+2\hat{k})}{\sqrt{5}}$
 (C) $\frac{(\hat{j}-2\hat{k})}{\sqrt{5}}$
 (D) $\frac{(\hat{j}+2\hat{k})}{\sqrt{5}}$

Q44. [Marks: 2 | MCQ]

Mathematical Physics · Matrices

Gate 2016	MCQ	2 M
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σ_x, σ_y and σ_z are the Pauli matrices. The expression $2\sigma_x\sigma_y + \sigma_y\sigma_x$ is equal to

(A) $-3i\sigma_z$

(B) $-i\sigma_z$

(C) $i\sigma_z$

(D) $3i\sigma_z$

Q45. [Marks: 2 | NAT]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2016	NAT	2 M
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A particle of mass $m = 0.1$ kg is initially at rest at origin. It starts moving with a uniform acceleration $\vec{a} = 10\hat{i} \text{ ms}^{-2}$ at $t = 0$. The action S of the particle, in units of J – s, at $t = 2$ s is ____ . (Give your answer upto two decimal places)

Q46. [Marks: 2 | MCQ]

Mathematical Physics · Fourier and Laplace transform

Gate 2016	MCQ	2 M
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A periodic function $f(x)$ of period 2π is defined in the interval $(-\pi < x < \pi)$ as:

$$f(x) = \begin{cases} -1, & -\pi < x < 0 \\ 1, & 0 < x < \pi \end{cases}$$

The appropriate Fourier series expansion for $f(x)$ is

- (A) $f(x) = (4/\pi)[\sin x + (\sin 3x)/3 + (\sin 5x)/5 + \dots]$
(B) $f(x) = (4/\pi)[\sin x - (\sin 3x)/3 + (\sin 5x)/5 - \dots]$
(C) $f(x) = (4/\pi)[\cos x + (\cos 3x)/3 + (\cos 5x)/5 \dots]$
(D) $f(x) = (4/\pi)[\cos x - (\cos 3x)/3 + (\cos 5x)/5 \dots]$

Q47. [Marks: 2 | NAT]

Solid State Physics · Crystallography

Gate 2016	NAT	2 M
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Atoms, which can be assumed to be hard spheres of radius R , are arranged in an fcc lattice with lattice constant a , such that each atom touches its nearest neighbours. Take the center of one of the atoms as the origin. Another atom of radius r (assumed to be hard sphere) is to be accommodated at a position $(0, a/2, 0)$ without distorting the lattice. The maximum value of r/R is ____ . (Give your answer upto two decimal places)

Q48. [Marks: 2 | MCQ]

Classical Mechanics · Special theory of relativity

Gate 2016	MCQ	2 M
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In an inertial frame of reference S , an observer finds two events occurring at the same time at coordinates $x_1 = 0$ and $x_2 = d$. A different inertial frame S' moves with velocity v with respect to S along the positive x -axis. An observer in S' also notices these two events and finds them to occur at times t'_1 and t'_2 and at positions x'_1 and x'_2 , respectively. If $\Delta t' = t'_2 - t'_1$, $\Delta x' = x'_2 - x'_1$ and

$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$, which of the following statements is

true ?

- (A) $\Delta t' = 0, \Delta x' = \gamma d$
- (B) $\Delta t' = 0, \Delta x' = d/\gamma$
- (C) $\Delta t' = -\gamma v d/c^2, \Delta x' = \gamma d$
- (D) $\Delta t' = -\gamma v d/c^2, \Delta x' = d/\gamma$

Q49. [Marks: 2 | NAT]

Solid State Physics · Semiconductor Physics

Gate 2016	NAT	2 M
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The energy vs. wave vector ($E - k$) relationship near the bottom of a band for a solid can be approximated as $E = A(ka)^2 + B(ka)^4$, where the lattice constant $a = 2.1\text{\AA}$. The values of A and B are 6.3×10^{-19} J and 3.2×10^{-20} J, respectively. At the bottom of the conduction band, the ratio of the effective mass of the electron to the mass of free electron is ____ . (Give your answer upto two decimal places)

(Take $\hbar = 1.05 \times 10^{-34}$ J – s, mass of free electron = 9.1×10^{-31} kg)

Q50. [Marks: 2 | MCQ]

Electromagnetism · EM Waves

Gate 2016	MCQ	2 M
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The electric field component of a plane electromagnetic wave travelling in vacuum is given by $\vec{E}(z, t) = E_0 \cos(kz - \omega t) \hat{i}$. The Poynting vector for the wave is

- (A) $(c\epsilon_0/2)E_0^2 \cos^2(kz - \omega t) \hat{j}$
 (B) $(c\epsilon_0/2)E_0^2 \cos^2(kz - \omega t) \hat{k}$
 (C) $c\epsilon_0 E_0^2 \cos^2(kz - \omega t) \hat{j}$
 (D) $c\epsilon_0 E_0^2 \cos^2(kz - \omega t) \hat{k}$

Q51. [Marks: 2 | NAT]

Statistical Mechanics · Microstates

Gate 2016	NAT	2 M
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Consider a system having three energy levels with energies $0, 2\epsilon$ and 3ϵ , with respective degeneracies of 2, 2 and 3. Four bosons of spin zero have to be accommodated in these levels such that the total energy of the system is 10ϵ . The number of ways in which it can be done is ____ .

Q52. [Marks: 2 | MCQ]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2016	MCQ	2 M
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The Lagrangian of a system is given by

$$L = \frac{1}{2} ml^2 [\dot{\theta}^2 + \sin^2 \theta \dot{\phi}^2] - mgl \cos \theta,$$

where m , l and g are constants.

Which of the following is conserved?

(A) $\dot{\phi} \sin^2 \theta$

(B) $\dot{\phi} \sin \theta$

(C) $\frac{\dot{\phi}}{\sin \theta}$

(D) $\frac{\dot{\phi}}{\sin^2 \theta}$

Q53. [Marks: 2 | NAT]

Nuclear and Particle Physics · Nuclear Force, deuteron problem and scatteri

Gate 2016	NAT	2 M
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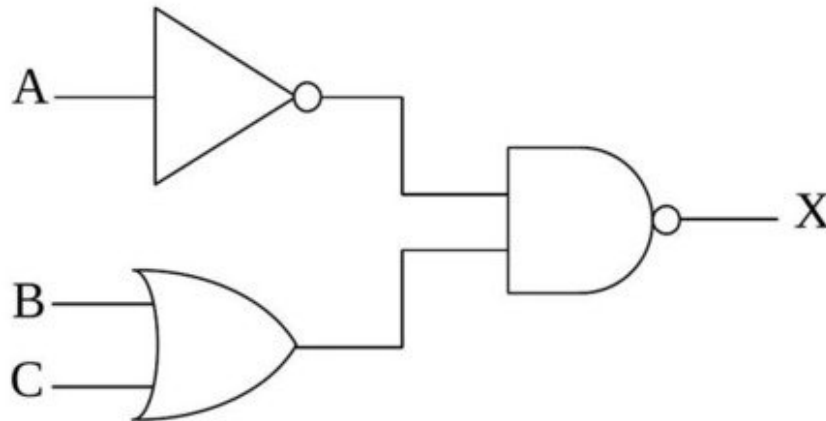
Protons and α -particles of equal initial momenta are scattered off a gold foil in a Rutherford scattering experiment. The scattering cross sections for proton on gold and α -particle on gold are σ_p and σ_α respectively. The ratio σ_α/σ_p is ____

Q54. [Marks: 2 | MCQ]

Electronics · Logic Gates

Gate 2016	MCQ	2 M
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For the digital circuit given below, the output X is



- (A) $\overline{\overline{A} + B \cdot C}$
(B) $\overline{\overline{A} \cdot (B + C)}$
(C) $\overline{A} \cdot (B + C)$
(D) $A + \overline{(B \cdot C)}$

Q55. [Marks: 2 | MCQ]

Solid State Physics · Free electron model

Gate 2016	MCQ	2 M
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The Fermi energies of two metals X and Y are 5 eV and 7 eV and their Debye temperatures are 170 K and 340 K, respectively. The molar specific heats of these metals at constant volume at low temperatures can be written as

$$(C_V)_X = \gamma_X T + A_X T^3 \text{ and } (C_V)_Y = \gamma_Y T + A_Y T^3,$$

where γ and A are constants. Assuming that the thermal effective mass of the electrons in the two metals are same, which of the following is correct?

- (A) $\frac{\gamma_X}{\gamma_Y} = \frac{7}{5}, \frac{A_X}{A_Y} = 8$
- (B) $\frac{\gamma_X}{\gamma_Y} = \frac{7}{5}, \frac{A_X}{A_Y} = \frac{1}{8}$
- (C) $\frac{\gamma_X}{\gamma_Y} = \frac{5}{7}, \frac{A_X}{A_Y} = \frac{1}{8}$
- (D) $\frac{\gamma_X}{\gamma_Y} = \frac{5}{7}, \frac{A_X}{A_Y} = 8$

Q56. [Marks: 2 | MCQ]

Statistical Mechanics · Canonical ensemble

Gate 2016	MCQ	2 M
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A two-level system has energies zero and E . The level with zero energy is non-degenerate, while the level with energy E is triply degenerate. The mean energy of a classical particle in this system at a temperature T is

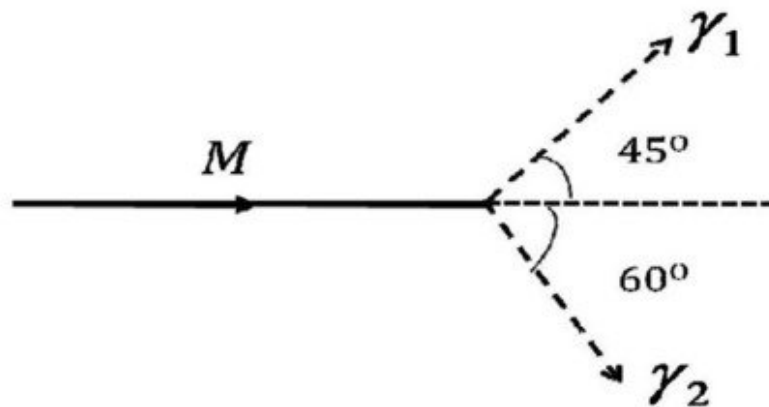
- (A) $\frac{Ee^{-E/k_B T}}{1+3e^{-E/k_B T}}$
- (B) $\frac{Ee^{-E/k_B T}}{1+e^{-E/k_B T}}$
- (C) $\frac{3Ee^{-E/k_B T}}{1+e^{-E/k_B T}}$
- (D) $\frac{3Ee^{-E/k_B T}}{1+3e^{-E/k_B T}}$

Q57. [Marks: 2 | NAT]

Nuclear and Particle Physics · Radioactivity

Gate 2016	NAT	2 M
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A particle of rest mass M is moving along the positive x -direction. It decays into two photons γ_1 and γ_2 as shown in the figure. The energy of γ_1 is 1 GeV and the energy of γ_2 is 0.82 GeV. The value of M (in units of GeV/c^2) is ____ . (Give your answer upto two decimal places)



Q58. [Marks: 2 | MCQ]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2016	MCQ	2 M
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If x and p are the x components of the position and the momentum operators of a particle respectively, the commutator $[x^2, p^2]$ is

- (A) $i\hbar(xp - px)$
- (B) $2i\hbar(xp - px)$
- (C) $i\hbar(xp + px)$
- (D) $2i\hbar(xp + px)$

Q59. [Marks: 2 | MCQ]

Electromagnetism · Magnetism

Gate 2016	MCQ	2 M
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The $x - y$ plane is the boundary between free space and a magnetic material with relative permeability μ_r . The magnetic field in the free space is $B_x\hat{i} + B_z\hat{k}$. The magnetic field in the magnetic material is

- (A) $B_x\hat{i} + B_z\hat{k}$
- (B) $B_x\hat{i} + \mu_r B_z\hat{k}$
- (C) $\frac{1}{\mu_r} B_x\hat{i} + B_z\hat{k}$
- (D) $\mu_r B_x\hat{i} + B_z\hat{k}$

Q60. [Marks: 2 | MCQ]

Quantum Mechanics · Orbital angular momentum and hydrogen atom

Gate 2016	MCQ	2 M
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Let $|l, m\rangle$ be the simultaneous eigenstates of L^2 and L_z . Here \vec{L} is the angular momentum operator with Cartesian components (L_x, L_y, L_z) , l is the angular momentum quantum number and m is the azimuthal quantum number. The value of

$\langle 1, 0 | (L_x + iL_y) | 1, -1 \rangle$ is

- (A) 0
- (B) \hbar
- (C) $\sqrt{2}\hbar$
- (D) $\sqrt{3}\hbar$

Q61. [Marks: 2 | MCQ]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2016	MCQ	2 M
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For the parity operator P , which of the following statements is NOT true?

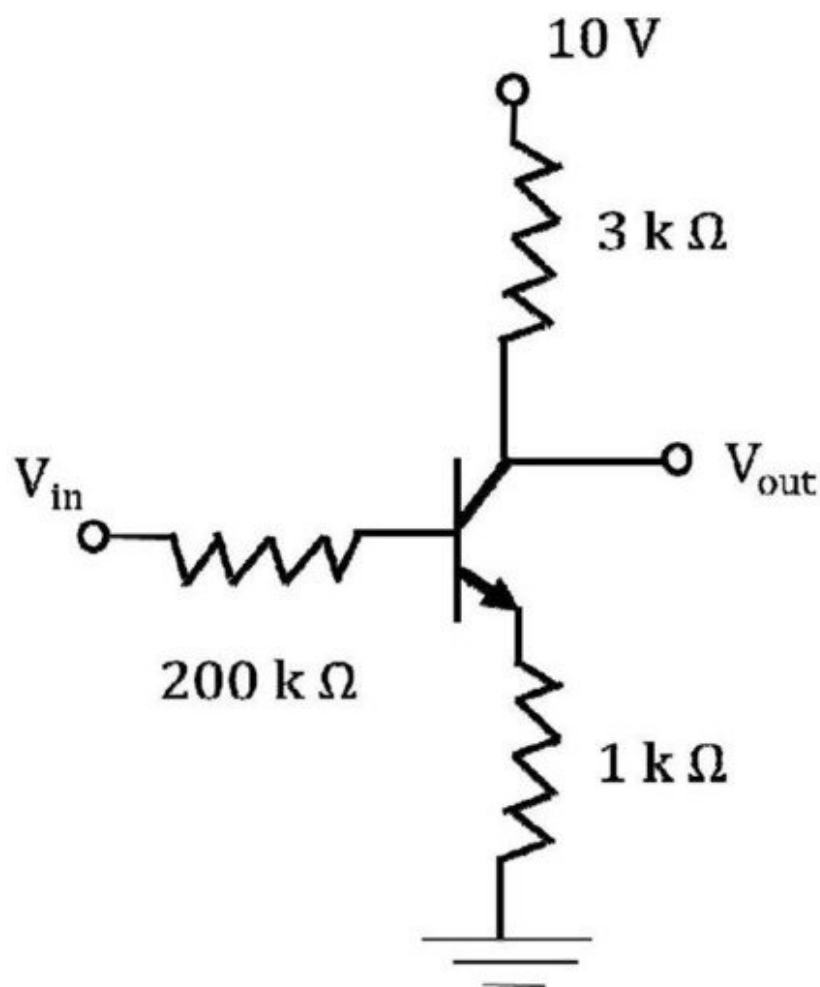
- (A) $P^\dagger = P$
- (B) $P^2 = -P$
- (C) $P^2 = I$
- (D) $P^\dagger = P^{-1}$

Q62. [Marks: 2 | NAT]

Electronics · Transistors

Gate 2016	NAT	2 M
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For the transistor shown in the figure, assume $V_{BE} = 0.7 \text{ V}$ and $\beta_{dc} = 100$. If $V_{in} = 5 \text{ V}$, V_{out} (in Volts) is ____ . (Give your answer upto one decimal place)



Q63. [Marks: 2 | NAT]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2016	NAT	2 M
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The state of a system is given by

$$|\psi\rangle = |\phi_1\rangle + 2|\phi_2\rangle + 3|\phi_3\rangle$$

where $|\phi_1\rangle$, $|\phi_2\rangle$ and $|\phi_3\rangle$ form an orthonormal set.

The probability of finding the system in the state $|\phi_2\rangle$ is ____ . (Give your answer upto two decimal places)

Q64. [Marks: 2 | MCQ]

Nuclear and Particle Physics · Shell Model

Gate 2016	MCQ	2 M
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According to the nuclear shell model, the respective ground state spin-parity values of ${}^{15}_8\text{O}$ and ${}^{17}_8\text{O}$ nuclei are

- (A) $\frac{1}{2}^+$, $\frac{1}{2}^-$
- (B) $\frac{1}{2}^-$, $\frac{5}{2}^+$
- (C) $\frac{3}{2}^-$, $\frac{5}{2}^+$
- (D) $\frac{3}{2}^-$, $\frac{1}{2}^-$

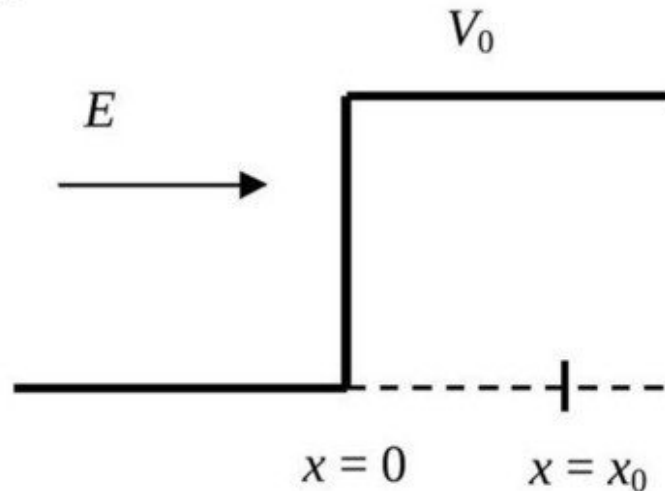
Q65. [Marks: 2 | MCQ]

Quantum Mechanics · Potential Well

Gate 2016	MCQ	2 M
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A particle of mass m and energy E , moving in the positive x direction, is incident on a step potential at $x = 0$, as indicated in the figure. The height of the potential is V_0 , where $V_0 > E$. At $x = x_0$, where $x_0 > 0$, the probability of finding the electron is $1/e$ times the probability of finding it at $x = 0$. If

$$\alpha = \sqrt{\frac{2m(V_0 - E)}{\hbar^2}}, \text{ the value of } x_0 \text{ is}$$



- (A) $\frac{2}{\alpha}$
 (B) $\frac{1}{\alpha}$
 (C) $\frac{1}{2\alpha}$
 (D) $\frac{1}{4\alpha}$

Answer Key

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

Q.No	Subject	Topic	Type	Marks	Answer
Q1	General Aptitude	Geometry	MCQ	1	B
Q2	General Aptitude	English	MCQ	1	A
Q3	General Aptitude	English	MCQ	1	D
Q4	General Aptitude	Reasoning	MCQ	1	C
Q5	General Aptitude	Geometry	MCQ	1	B
Q6	General Aptitude	Reasoning	MCQ	2	C
Q7	General Aptitude	Reasoning	MCQ	2	C
Q8	General Aptitude	Reasoning	MCQ	2	C
Q9	General Aptitude	Reasoning	MCQ	2	A
Q10	General Aptitude	Mathematical Analysis	MCQ	2	C
Q11	Mathematical Physics	Differential Equations	MCQ	1	D
Q12	Electromagnetism	Magnetism	MCQ	1	C
Q13	Atomic and Molecular Ph...	ESR/EPR/NMR	MCQ	1	C
Q14	Atomic and Molecular Ph...	Vector Model	NAT	1	0 to 0
Q15	Atomic and Molecular Ph...	Effects in atomic physics	MCQ	1	A
Q16	Nuclear and Particle Phy...	Particle Physics	MCQ	1	B
Q17	Electromagnetism	Magnetism	NAT	1	0.17
Q18	Statistical Mechanics	Quantum Statistical Mechanics	NAT	1	0.25
Q19	Statistical Mechanics	Microcanonical ensemble	NAT	1	0.5
Q20	Thermodynamics	Thermodynamic Potential	MCQ	1	A
Q21	Statistical Mechanics	Microcanonical ensemble	NAT	1	0.08
Q22	Mathematical Physics	Complex Analysis	MCQ	1	A
Q23	Optics	Interference and Diffraction	NAT	1	0.38
Q24	Solid State Physics	Hall Effect	MCQ	1	C
Q25	Solid State Physics	Lattice vibration	MCQ	1	A
Q26	Quantum Mechanics	Basics Quantum Mechanics	MCQ	1	B
Q27	Classical Mechanics	Special theory of relativity	NAT	1	1.72 to 1.74
Q28	Solid State Physics	Semiconductor Physics	NAT	1	400
Q29	Classical Mechanics	Small Oscillations	NAT	1	2.41 to 2.49
Q30	Classical Mechanics	Central Forces	MCQ	1	B
Q31	Nuclear and Particle Phy...	Radioactivity	MCQ	1	B
Q32	Quantum Mechanics	Scattering Theory	MCQ	1	A
Q33	Quantum Mechanics	Scattering Theory	NAT	1	0.08
Q34	Atomic and Molecular Ph...	Effects in atomic physics	NAT	1	0.08
Q35	Solid State Physics	Magnetic properties of solids	MCQ	1	C
Q36	Electromagnetism	Electric field in matter	MCQ	2	D

Answer Key

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

Q.No	Subject	Topic	Type	Marks	Answer
Q37	Atomic and Molecular Ph...	Effects in atomic physics	NAT	2	12 or 6
Q38	Nuclear and Particle Phy...	Nuclear Force, deuteron problem an...	MCQ	2	C
Q39	Atomic and Molecular Ph...	Effects in atomic physics	MCQ	2	B
Q40	Quantum Mechanics	Potential Well	NAT	2	1.02
Q41	Nuclear and Particle Phy...	Particle detector and accelerator	NAT	2	80
Q42	Mathematical Physics	Tensors	MCQ	2	D
Q43	Mathematical Physics	Vector Analysis	MCQ	2	B
Q44	Mathematical Physics	Matrices	MCQ	2	C
Q45	Classical Mechanics	Lagrangian and Hamiltonian	NAT	2	26.65 to 26.68
Q46	Mathematical Physics	Fourier and Laplace transform	MCQ	2	A
Q47	Solid State Physics	Crystallography	NAT	2	0.40 to 0.42
Q48	Classical Mechanics	Special theory of relativity	MCQ	2	C
Q49	Solid State Physics	Semiconductor Physics	NAT	2	0.20 to 0.24
Q50	Electromagnetism	EM Waves	MCQ	2	D
Q51	Statistical Mechanics	Microstates	NAT	2	0.76
Q52	Classical Mechanics	Lagrangian and Hamiltonian	MCQ	2	A
Q53	Nuclear and Particle Phy...	Nuclear Force, deuteron problem an...	NAT	2	0.17
Q54	Electronics	Logic Gates	MCQ	2	B
Q55	Solid State Physics	Free electron model	MCQ	2	A
Q56	Statistical Mechanics	Canonical ensemble	MCQ	2	D
Q57	Nuclear and Particle Phy...	Radioactivity	NAT	2	1.40 to 1.45
Q58	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	D
Q59	Electromagnetism	Magnetism	MCQ	2	D
Q60	Quantum Mechanics	Orbital angular momentum and hydr...	MCQ	2	C
Q61	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	B
Q62	Electronics	Transistors	NAT	2	5.5 to 5.9
Q63	Quantum Mechanics	Basics Quantum Mechanics	NAT	2	0.27 to 0.29
Q64	Nuclear and Particle Phy...	Shell Model	MCQ	2	B
Q65	Quantum Mechanics	Potential Well	MCQ	2	C