

PhysicsByAaryan

CSIR NET · GATE · JEST · BARC – Physics

GATE Physics 2019 — Full Question Paper

Previous Year Questions with Official Answer Key

Inside this PDF

- Every GATE Physics (PH) 2019 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 2019	MCQ	1M
-----------	-----	----

The fishermen, ___ the flood victims owed their lives, were rewarded by the government.

- (A) Whom
 - (B) to which
 - (C) to whom
 - (D) that
-

Q2. [Marks: 1 | MCQ]

General Aptitude · Reasoning

Gate 2019	MCQ	1M
-----------	-----	----

Some students were not involved in the strike.

If the above statement is true, which of the following conclusions is/are logically necessary?

1. Some who were involved in the strike were students.
2. No student was involved in the strike.
3. At least one student was involved in the strike.
4. Some who were not involved in the strike were students.

- (A) 1 and 2
(B) 3
(C) 4
(D) 2 and 3

Q3. [Marks: 1 | MCQ]

General Aptitude · Geometry

Gate 2019	MCQ	1M
-----------	-----	----

The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is ____ .

- (A) 17.1
- (B) 21.0
- (C) 33.1
- (D) 72.8

Q4. [Marks: 1 | MCQ]

General Aptitude · Reasoning

Gate 2019	MCQ	1M
-----------	-----	----

4 Five numbers 10, 7, 5, 4 and 2 are to be arranged in a sequence from left to right following the directions given below:

1. No two odd or even numbers are next to each other.
2. The second number from the left is exactly half of the left-most number.
3. The middle number is exactly twice the right-most number.

Which is the second number from the right?

- (A) 2
- (B) 4
- (C) 7
- (D) 10

Q5. [Marks: 1 | MCQ]

General Aptitude · English

Gate 2019	MCQ	1M
-----------	-----	----

Until Iran came along, India had never been ___ in kabaddi.

- (A) Defeated
- (B) Defeating
- (C) Defeat
- (D) defeatist

Q6. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2019	MCQ	2M
-----------	-----	----

Since the last one year, after a 125 basis point reduction in repo rate by the Reserve Bank of India, banking institutions have been making a demand to reduce interest rates on small saving schemes. Finally, the government announced yesterday a reduction in interest rates on small saving schemes to bring them on par with fixed deposit interest rates. Which one of the following statements can be inferred from the given passage?

- (A) Whenever the Reserve Bank of India reduces the repo rate, the interest rates on small saving schemes are also reduced
- (B) Interest rates on small saving schemes are always maintained on par with fixed deposit interest rates
- (C) The government sometimes takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes
- (D) A reduction in interest rates on small saving schemes follow only after a reduction in repo rate by the Reserve Bank of India

Q7. [Marks: 2 | MCQ]

General Aptitude · Mathematical Analysis

Gate 2019	MCQ	2M
-----------	-----	----

7 In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the Internet. Among these Internet users, only half buy goods from e-commerce portals. What is the percentage of these buyers in the country?

- (A) 10.50
- (B) 14.70
- (C) 15.00
- (D) 50.00

Q8. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2019	MCQ	2M
-----------	-----	----

The nomenclature of Hindustani music has changed over the centuries. Since the medieval period dhrupad styles were identified as baanis. Terms like gayaki and baaj were used to refer to vocal and instrumental styles, respectively. With the institutionalization of music education the term gharana became acceptable. Gharana originally referred to hereditary musicians from a particular lineage, including disciples and grand disciples. Which one of the following pairings is NOT correct?

- (A) dhrupad, baani
- (B) gayaki, vocal
- (C) baaj, institution
- (D) gharana, lineage

Q9. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2019	MCQ	2M
-----------	-----	----

Two trains started at 7AM from the same point. The first train travelled north at a speed of 80 km/h and the second train travelled south at a speed of 100 km/h. The time at which they were 540 km apart is ___ AM.

- (A) 9
- (B) 10
- (C) 11
- (D) 11.30

Q10. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2019	MCQ	2M
-----------	-----	----

"I read somewhere that in ancient times the prestige of a kingdom depended upon the number of taxes that it was able to levy on its people. It was very much like the prestige of a head-hunter in his own community." Based on the paragraph above, the prestige of a head-hunter depended upon

- (A) the prestige of the kingdom
- (B) the prestige of the heads
- (C) the number of taxes he could levy
- (D) the number of heads he could gather

Q11. [Marks: 1 | MCQ]

Solid State Physics · Superconductivity

Gate 2019	MCQ	1M
-----------	-----	----

The relative magnetic permeability of a type-I superconductor is

- (A) 0
- (B) -1
- (C) 2π
- (D) $\frac{1}{4\pi}$

Q12. [Marks: 1 | MCQ]

Nuclear and Particle Physics · Particle Physics

Gate 2019	MCQ	1M
-----------	-----	----

Considering baryon number and lepton number conservation laws, which of the following processes is/are allowed?

(i) $p \rightarrow \pi^0 + e^+ + \nu_e$

(ii) $e^+ + \nu_e \rightarrow \mu^+ + \nu_\mu$

(A) both (i) and (ii)

(B) only (i)

(C) only (ii)

(D) neither (i) nor (ii)

Q13. [Marks: 1 | MCQ]

Electronics · OPAMP

Gate 2019	MCQ	1M
-----------	-----	----

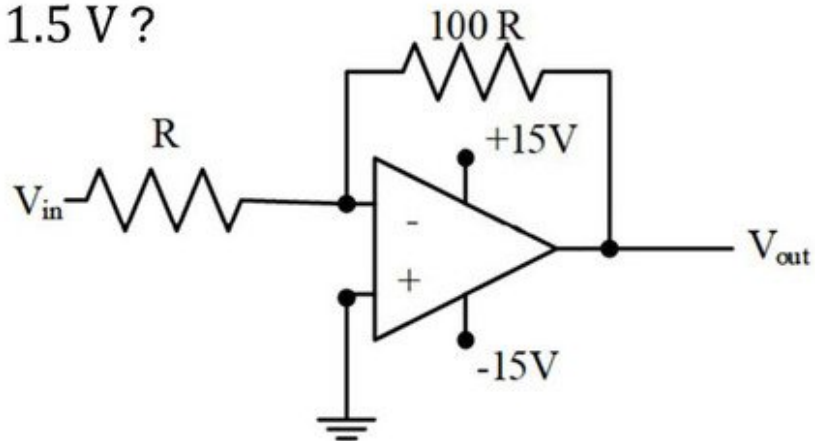
For the following circuit, what is the magnitude of V_{out} if $V_{in} = 1.5\text{ V}$?

(A) 0.015 V

(B) 0.15 V

(C) 15 V

(D) 150 V



Q14. [Marks: 1 | MCQ]

Mathematical Physics · Special functions

Gate 2019	MCQ	1M
-----------	-----	----

For the differential equation $\frac{d^2y}{dx^2} - n(n+1)\frac{y}{x^2} = 0$, where n is a constant, the product of its two independent solutions is

- (A) $\frac{1}{x}$
- (B) x
- (C) x^n
- (D) $\frac{1}{x^{n+1}}$

Q15. [Marks: 1 | MCQ]

Thermodynamics · Kinetic theory of gases

Gate 2019	MCQ	1M
-----------	-----	----

Consider a one-dimensional gas of N non-interacting particles of mass m with the Hamiltonian for a single particle given by,

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2(x^2 + 2x)$$

The high temperature specific heat in units of $R = Nk_B$ (k_B is the Boltzmann constant) is

- (A) 1
- (B) 1.5
- (C) 2
- (D) 2.5

Q16. [Marks: 1 | MCQ]

Quantum Mechanics · Perturbation Theory

Gate 2019	MCQ	1M
-----------	-----	----

An electric field $\vec{E} = E_0 \hat{z}$ is applied to a Hydrogen atom in $n = 2$ excited state. Ignoring spin, the $n = 2$ state is fourfold degenerate, which in the $|l, m\rangle$ basis are given by $|0,0\rangle$, $|1,1\rangle$, $|1,0\rangle$ and $|1,-1\rangle$. If H' is the interaction Hamiltonian corresponding to the applied electric field, which of the following matrix elements is nonzero?

- (A) $\langle 0,0|H'|0,0\rangle$
- (B) $\langle 0,0|H'|1,1\rangle$
- (C) $\langle 0,0|H'|1,0\rangle$
- (D) $\langle 0,0|H'|1,-1\rangle$

Q17. [Marks: 1 | MCQ]

Quantum Mechanics · Quantum Statistical Mechanics

Gate 2019	MCQ	1M
-----------	-----	----

A large number N of ideal bosons, each of mass m , are trapped in a three-dimensional potential $V(r) = \frac{m\omega^2 r^2}{2}$. The bosonic system is kept at temperature T which is much lower than the Bose-Einstein condensation temperature T_c . The chemical potential (μ) satisfies

- (A) $\mu \leq \frac{3}{2} \hbar\omega$
- (B) $2\hbar\omega > \mu > \frac{3}{2} \hbar\omega$
- (C) $3\hbar\omega > \mu > 2\hbar\omega$
- (D) $\mu = 3\hbar\omega$

Q18. [Marks: 1 | MCQ]

Mathematical Physics · Matrices

Gate 2019	MCQ	1M
-----------	-----	----

During a rotation, vectors along the axis of rotation remain unchanged. For the rotation matrix

$\begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & -1 \\ -1 & 0 & 0 \end{pmatrix}$, the unit vector along the axis of rotation is

- (A) $\frac{1}{3}(2\hat{i} - \hat{j} + 2\hat{k})$
- (B) $\frac{1}{\sqrt{3}}(\hat{i} + \hat{j} - \hat{k})$
- (C) $\frac{1}{\sqrt{3}}(\hat{i} - \hat{j} - \hat{k})$
- (D) $\frac{1}{3}(2\hat{i} + 2\hat{j} - \hat{k})$

Q19. [Marks: 1 | MCQ]

Quantum Mechanics · Spin and Total Angular momentum

Gate 2019	MCQ	1M
-----------	-----	----

For a spin $\frac{1}{2}$ particle, let $|\uparrow\rangle$ and $|\downarrow\rangle$ denote its spin up and spin down states, respectively. If $|a\rangle = \frac{1}{\sqrt{2}}(|\uparrow\rangle|\downarrow\rangle + |\downarrow\rangle|\uparrow\rangle)$ and $|b\rangle = \frac{1}{\sqrt{2}}(|\uparrow\rangle|\downarrow\rangle - |\downarrow\rangle|\uparrow\rangle)$ are composite states of two such particles, which of the following statements is true for their total spin S ?

- (A) $S = 1$ for $|a\rangle$, and $|b\rangle$ is not an eigenstate of the operator \hat{S}^2
- (B) $|a\rangle$ is not an eigenstate of the operator \hat{S}^2 , and $S = 0$ for $|b\rangle$
- (C) $S = 0$ for $|a\rangle$, and $S = 1$ for $|b\rangle$
- (D) $S = 1$ for $|a\rangle$, and $S = 0$ for $|b\rangle$

Q20. [Marks: 1 | MCQ]

Classical Mechanics · Canonical Transformation and Poisson bracket

Gate 2019	MCQ	1M
-----------	-----	----

10 Consider a transformation from one set of generalized coordinate and momentum (q, p) to another set (Q, P) denoted by,

$$Q = pq^s; P = q^r$$

where s and r are constants. The transformation is canonical if

- (A) $s = 0$ and $r = 1$
- (B) $s = 2$ and $r = -1$
- (C) $s = 0$ and $r = -1$
- (D) $s = 2$ and $r = 1$

Q21. [Marks: 1 | MCQ]

Solid State Physics · Lattice vibration

Gate 2019	MCQ	1M
-----------	-----	----

In order to estimate the specific heat of phonons, the appropriate method to apply would be

- (A) Einstein model for acoustic phonons and Debye model for optical phonons
 - (B) Einstein model for optical phonons and Debye model for acoustic phonons
 - (C) Einstein model for both optical and acoustic phonons
 - (D) Debye model for both optical and acoustic phonons
-

Q22. [Marks: 1 | MCQ]

Mathematical Physics · Complex Analysis

Gate 2019	MCQ	1M
-----------	-----	----

The pole of the function $f(z) = \cot z$ at $z = 0$ is

- (A) a removable singularity
- (B) an essential singularity
- (C) a simple pole
- (D) a second order pole

Q23. [Marks: 1 | MCQ]

Nuclear and Particle Physics · Particle Physics

Gate 2019	MCQ	1M
-----------	-----	----

13 A massive particle X in free space decays spontaneously into two photons. Which of the following statements is true for X ?

- (A) X is charged
- (B) Spin of X must be greater than or equal to 2
- (C) X is a boson
- (D) X must be a baryon

Q24. [Marks: 1 | MCQ]

Optics · Polarization

Gate 2019	MCQ	1M
-----------	-----	----

The electric field of an electromagnetic wave is given by $\vec{E} = 3\sin(kz - \omega t)\hat{x} + 4\cos(kz - \omega t)\hat{y}$. The wave is

- (A) linearly polarized at an angle $\tan^{-1}\left(\frac{4}{3}\right)$ from the x-axis
- (B) linearly polarized at an angle $\tan^{-1}\left(\frac{3}{4}\right)$ from the x-axis
- (C) elliptically polarized in clockwise direction when seen travelling towards the observer
- (D) elliptically polarized in counter-clockwise direction when seen travelling towards the observer

Q25. [Marks: 1 | MCQ]

Nuclear and Particle Physics · Shell Model

Gate 2019	MCQ	1M
-----------	-----	----

The nuclear spin and parity of ${}_{20}^{40}\text{Ca}$ in its ground state is

- (A) 0^+
- (B) 0^-
- (C) 1^+
- (D) 1^-

Q26. [Marks: 1 | MCQ]

Electromagnetism · Electrostatics

Gate 2019	MCQ	1M
-----------	-----	----

An infinitely long thin cylindrical shell has its axis coinciding with the z -axis. It carries a surface charge density $\sigma_0 \cos \phi$, where ϕ is the polar angle and σ_0 is a constant. The magnitude of the electric field inside the cylinder is

- (A) 0
- (B) $\frac{\sigma_0}{2\epsilon_0}$
- (C) $\frac{\sigma_0}{3\epsilon_0}$
- (D) $\frac{\sigma_0}{4\epsilon_0}$

Q27. [Marks: 1 | NAT]

Solid State Physics · Lattice vibration

Gate 2019	NAT	1M
-----------	-----	----

Consider a three-dimensional crystal of N inert gas atoms. The total energy is given by

$$U(R) = 2N\epsilon \left[p \left(\frac{\sigma}{R} \right)^{12} - q \left(\frac{\sigma}{R} \right)^6 \right],$$

where $p = 12.13$, $q = 14.45$, and R is the nearest neighbour distance between two atoms. The two constants, ϵ and R , have the dimensions of energy and length, respectively. The equilibrium separation between two nearest neighbour atoms in units of σ (rounded off to two decimal places) is ____

Q28. [Marks: 1 | NAT]

Statistical Mechanics · Quantum Statistical Mechanics

Gate 2019	NAT	1M
-----------	-----	----

The energy-wavevector ($E - k$) dispersion relation for a particle in two dimensions is $E = Ck$, where C is a constant. If its density of states $D(E)$ is proportional to E^p then the value of p is ____

Q29. [Marks: 1 | NAT]

Electromagnetism · Electrodynamics

Gate 2019	NAT	1M
-----------	-----	----

A circular loop made of a thin wire has radius 2 cm and resistance 2Ω . It is placed perpendicular to a uniform magnetic field of magnitude $|\vec{B}_0| = 0.01$ Tesla. At time $t = 0$ the field starts decaying as $\vec{B} = \vec{B}_0 e^{-t/t_0}$, where $t_0 = 1$ s. The total charge that passes through a cross section of the wire during the decay is Q . The value of Q in μC (rounded off to two decimal places) is ____

Q30. [Marks: 1 | NAT]

Electromagnetism · EM Waves

Gate 2019	NAT	1M
-----------	-----	----

The electric field of an electromagnetic wave in vacuum is given by

$$\vec{E} = E_0 \cos(3y + 4z - 1.5 \times 10^9 t) \hat{x}$$

The wave is reflected from the $z = 0$ surface. If the pressure exerted on the surface is $\alpha \epsilon_0 E_0^2$, the value of α (rounded off to one decimal place) is

Q31. [Marks: 1 | NAT]

Quantum Mechanics · Quantum Harmonic Oscillator

Gate 2019	NAT	1M
-----------	-----	----

The Hamiltonian for a quantum harmonic oscillator of mass m in three dimensions is

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 r^2$$

where ω is the angular frequency. The expectation value of r^2 in the first excited state of the oscillator in units of $\frac{\hbar}{m\omega}$ (rounded off to one decimal place) is

Q32. [Marks: 1 | NAT]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2019	NAT	1M
-----------	-----	----

The Hamiltonian for a particle of mass m is $H = \frac{p^2}{2m} + kqt$ where q and p are the generalized coordinate and momentum, respectively, t is time and k is a constant. For the initial condition, $q = 0$ and $p = 0$ at $t = 0$, $q(t) \propto t^\alpha$. The value of α is ____

Q33. [Marks: 1 | NAT]

Statistical Mechanics · Quantum Statistical Mechanics

Gate 2019	NAT	1M
-----------	-----	----

At temperature T Kelvin (K), the value of the Fermi function at an energy 0.5 eV above the Fermi energy is 0.01 . Then T , to the nearest integer, is ____ ($k_B = 8.62 \times 10^{-5}$ eV/K)

Q34. [Marks: 1 | NAT]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2019	NAT	1M
-----------	-----	----

Let $|\psi_1\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$, $|\psi_2\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$ represent two possible states of a two-level quantum system. The state obtained by the incoherent superposition of $|\psi_1\rangle$ and $|\psi_2\rangle$ is given by a density matrix that is defined as $\rho \equiv c_1|\psi_1\rangle\langle\psi_1| + c_2|\psi_2\rangle\langle\psi_2|$. If $c_1 = 0.4$ and $c_2 = 0.6$, the matrix element ρ_{22} (rounded off to one decimal place) is ____

Q35. [Marks: 1 | NAT]

Solid State Physics · Superconductivity

Gate 2019	NAT	1M
-----------	-----	----

A conventional type-I superconductor has a critical temperature of 4.7 K at zero magnetic field and a critical magnetic field of 0.3 Tesla at 0 K. The critical field in Tesla at 2 K (rounded off to three decimal places) is ____

Q36. [Marks: 2 | MCQ]

Electronics · Logic Gates

Gate 2019	MCQ	2M
-----------	-----	----

Consider the following Boolean expression:

$$(\bar{A} + \bar{B})[\overline{A(B + C)}] + A(\bar{B} + \bar{C})$$

It can be represented by a single three-input logic gate. Identify the gate.

- (A) AND
- (B) OR
- (C) XOR
- (D) NAND

Q37. [Marks: 2 | MCQ]

Mathematical Physics · Complex Analysis

Gate 2019	MCQ	2M
-----------	-----	----

The value of the integral $\int_{-\infty}^{\infty} \frac{\cos(kx)}{x^2+a^2} dx$, where $k > 0$ and $a > 0$, is

- (A) $\frac{\pi}{a} e^{-ka}$
- (B) $\frac{2\pi}{a} e^{-ka}$
- (C) $\frac{\pi}{2a} e^{-ka}$
- (D) $\frac{3\pi}{2a} e^{-ka}$

Q39. [Marks: 2 | MCQ]

Electromagnetism · Magnetism

Gate 2019	MCQ	2M
-----------	-----	----

A solid cylinder of radius R has total charge Q distributed uniformly over its volume. It is rotating about its axis with angular speed ω . The magnitude of the total magnetic moment of the cylinder is

- (A) $QR^2\omega$
- (B) $\frac{1}{2}QR^2\omega$
- (C) $\frac{1}{4}QR^2\omega$
- (D) $\frac{1}{8}QR^2\omega$

Q40. [Marks: 2 | MCQ]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2019	MCQ	2M
-----------	-----	----

Consider the motion of a particle along the x -axis in a potential $V(x) = F|x|$. Its ground state energy E_0 is estimated using the uncertainty principle.

Then E_0 is proportional to

(A) $F^{\frac{1}{3}}$

(B) $F^{\frac{1}{2}}$

(C) $F^{\frac{2}{5}}$

(D) $F^{\frac{2}{3}}$

Q41. [Marks: 2 | MCQ]

Electronics · AD/DA conversion

Gate 2019	MCQ	2M
-----------	-----	----

A 3-bit analog-to-digital converter is designed to digitize analog signals ranging from 0 V to 10 V . For this converter, the binary output corresponding to an input of 6 V is

- (A) 011
- (B) 101
- (C) 100
- (D) 010

Q42. [Marks: 2 | MCQ]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2019	MCQ	2M
-----------	-----	----

The Hamiltonian operator for a two-level quantum system is $H = \begin{pmatrix} E_1 & 0 \\ 0 & E_2 \end{pmatrix}$. If the state of the system at $t = 0$ is given by $|\psi(0)\rangle = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ then $|\langle\psi(0) | \psi(t)\rangle|^2$ at a later time t is

- (A) $\frac{1}{2} (1 + e^{-(E_1 - E_2)t/\hbar})$
- (B) $\frac{1}{2} (1 - e^{-(E_1 - E_2)t/\hbar})$
- (C) $\frac{1}{2} (1 + \cos[(E_1 - E_2)t/\hbar])$
- (D) $\frac{1}{2} (1 - \cos[(E_1 - E_2)t/\hbar])$

Q43. [Marks: 2 | MCQ]

Solid State Physics · Tight binding model

Gate 2019	MCQ	2M
-----------	-----	----

A particle of mass m moves in a lattice along the x -axis in a periodic potential $V(x) = V(x + d)$ with periodicity d . The corresponding Brillouin zone extends from $-k_0$ to k_0 with these two k -points being equivalent. If a weak force F in the x -direction is applied to the particle, it starts a periodic motion with time period T . Using the equation of motion

$$F = \frac{dp_{\text{crystal}}}{dt}$$
 for a particle moving in a band,

where p_{crystal} is the crystal momentum of the particle, the period T is found to be (h is Planck constant)

(A) $\sqrt{\frac{2md}{F}}$

(B) $2\sqrt{\frac{2md}{F}}$

(C) $\frac{2h}{Fd}$

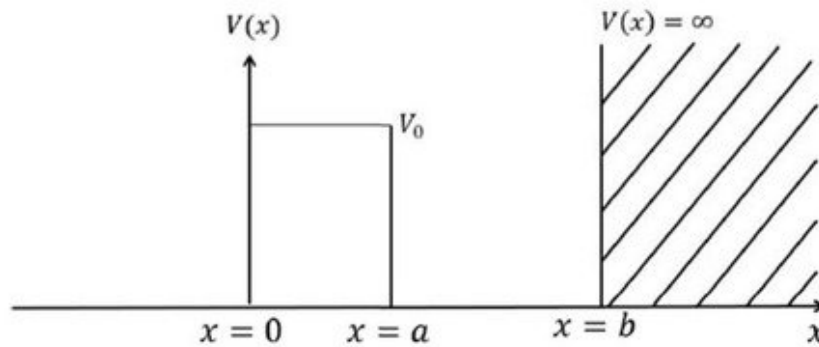
(D) $\frac{h}{Fd}$

Q44. [Marks: 2 | MCQ]

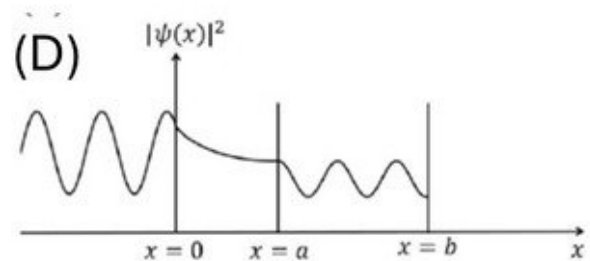
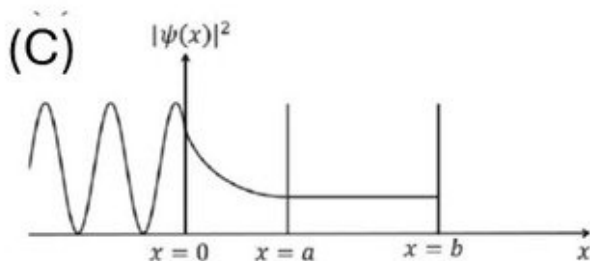
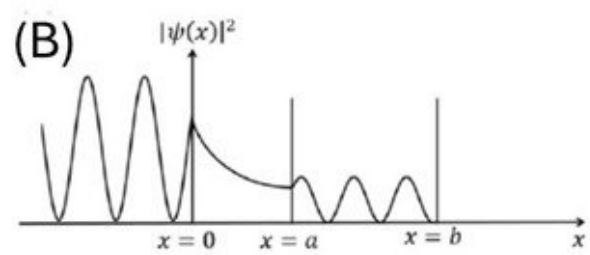
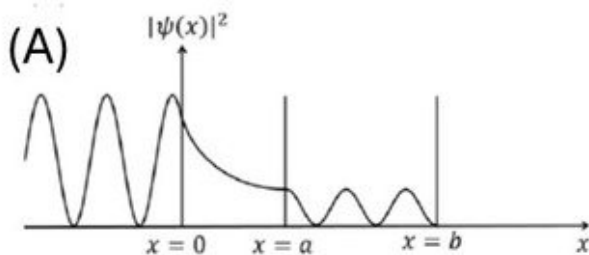
Quantum Mechanics · Potential Well

Gate 2019	MCQ	2M
-----------	-----	----

Consider a potential barrier $V(x)$ of the form:



where V_0 is a constant. For particles of energy $E < V_0$ incident on this barrier from the left, which of the following schematic diagrams best represents the probability density $|\psi(x)|^2$ as a function of x .



Q45. [Marks: 2 | MCQ]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2019	MCQ	2M
-----------	-----	----

The spin-orbit interaction term of an electron moving in a central field is written as $f(r)\vec{l} \cdot \vec{s}$, where r is the radial distance of the electron from the origin. If an electron moves inside a uniformly charged sphere, then

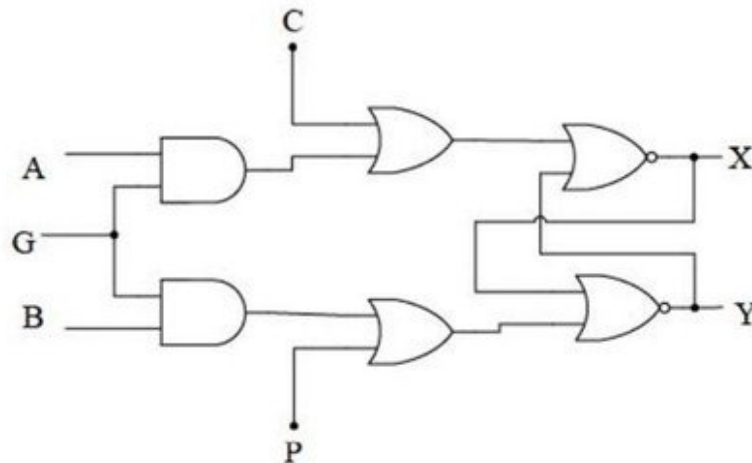
- (A) $f(r) = \text{constant}$
- (B) $f(r) \propto r^{-1}$
- (C) $f(r) \propto r^{-2}$
- (D) $f(r) \propto r^{-3}$

Q46. [Marks: 2 | MCQ]

Electronics · Logic Gates

Gate 2019	MCQ	2M
-----------	-----	----

For the following circuit, the correct logic values for the entries X_2 and Y_2 in the truth table are



- (A) 1 and 0
- (B) 0 and 0
- (C) 0 and 1
- (D) 1 and 1

G	A	B	P	C	X	Y
1	0	1	0	0	0	1
0	0	0	1	0	X_2	Y_2
1	0	0	0	1	0	1

Q47. [Marks: 2 | MCQ]

Optics · Polarization

Gate 2019	MCQ	2M
-----------	-----	----

In a set of N successive polarizers, the m^{th} polarizer makes an angle $\left(\frac{m\pi}{2N}\right)$ with the vertical. A vertically polarized light beam of intensity I_0 is incident on two such sets with $N = N_1$ and $N = N_2$, where $N_2 > N_1$. Let the intensity of light beams coming out be $I(N_1)$ and $I(N_2)$, respectively. Which of the following statements is correct about the two outgoing beams?

- (A) $I(N_2) > I(N_1)$; the polarization in each case is vertical
- (B) $I(N_2) < I(N_1)$; the polarization in each case is vertical
- (C) $I(N_2) > I(N_1)$; the polarization in each case is horizontal
- (D) $I(N_2) < I(N_1)$; the polarization in each case is horizontal

Q48. [Marks: 2 | MCQ]

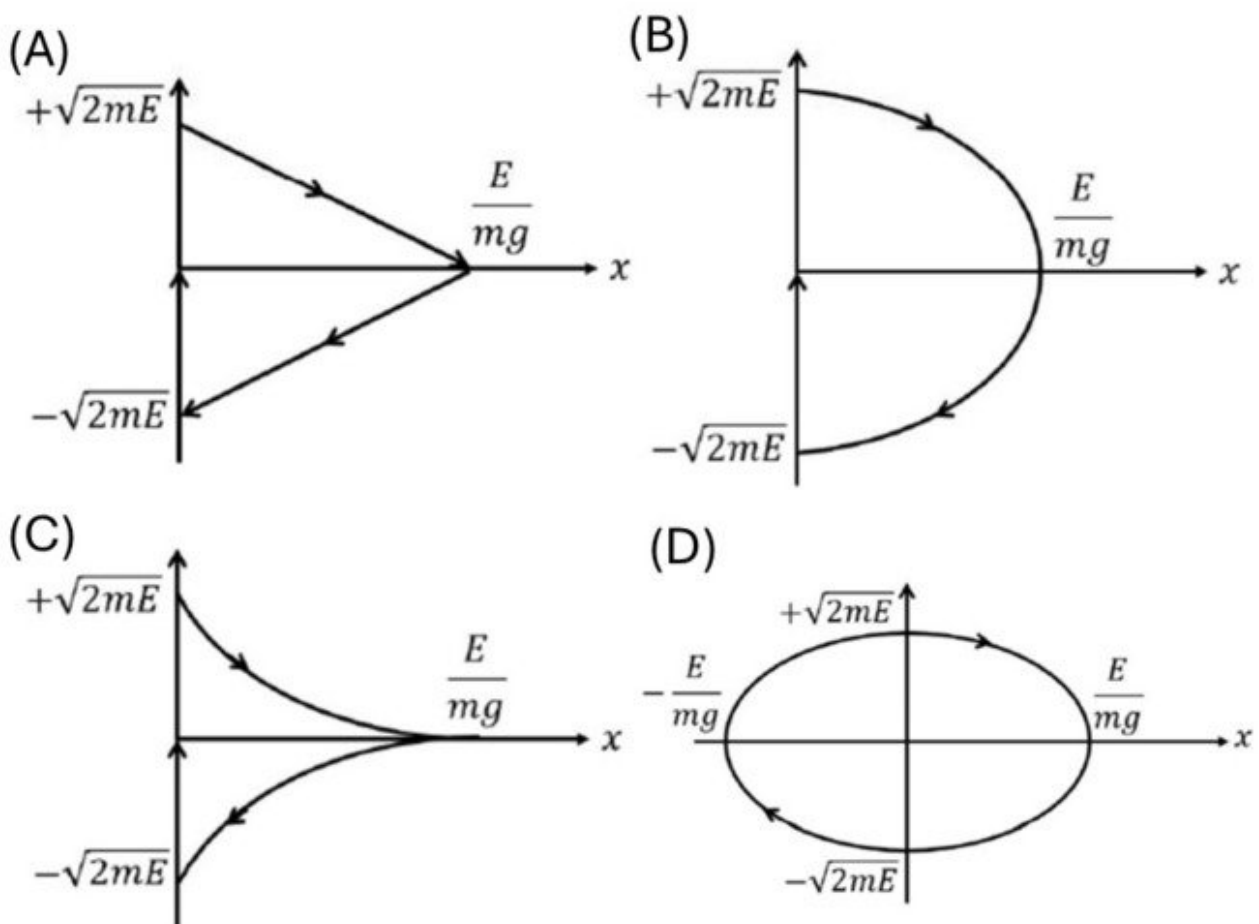
Classical Mechanics · Phase diagram

Gate 2019	MCQ	2M
-----------	-----	----

A ball bouncing off a rigid floor is described by the potential energy function

$$V(x) = \begin{cases} mgx & \text{for } x > 0 \\ \infty & \text{for } x \leq 0 \end{cases}$$

Which of the following schematic diagrams best represents the phase space plot of the ball?

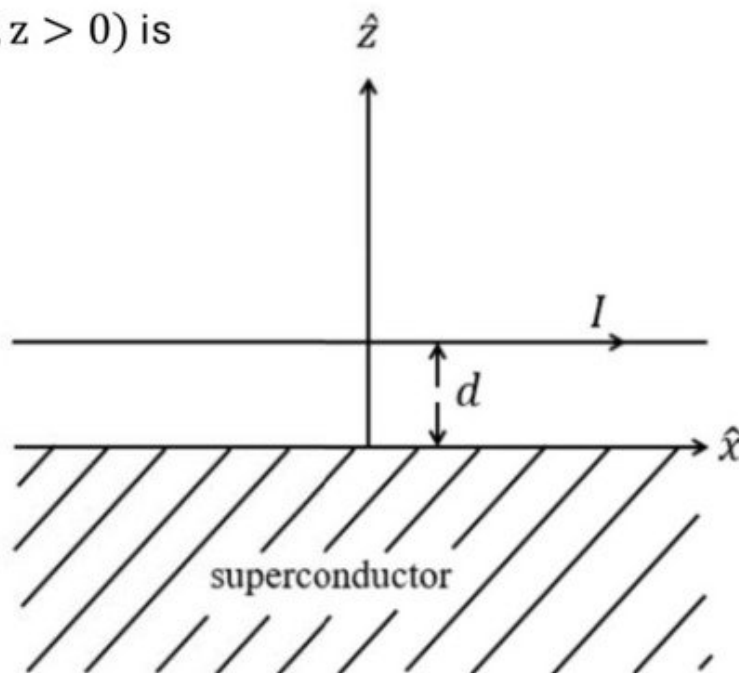


Q49. [Marks: 2 | MCQ]

Solid State Physics · Superconductivity

Gate 2019	MCQ	2M
-----------	-----	----

An infinitely long wire parallel to the x -axis is kept at $z = d$ and carries a current I in the positive x direction above a superconductor filling the region $z \leq 0$ (see figure). The magnetic field \vec{B} inside the superconductor is zero so that the field just outside the superconductor is parallel to its surface. The magnetic field due to this configuration at a point $(x, y, z > 0)$ is



- (A) $\left(\frac{\mu_0 I}{2\pi}\right) \frac{-(z-d)\hat{j} + y\hat{k}}{[y^2 + (z-d)^2]}$
- (B) $\left(\frac{\mu_0 I}{2\pi}\right) \left[\frac{-(z-d)\hat{j} + y\hat{k}}{y^2 + (z-d)^2} + \frac{(z+d)\hat{j} - y\hat{k}}{y^2 + (z+d)^2} \right]$
- (C) $\left(\frac{\mu_0 I}{2\pi}\right) \left[\frac{-(z-d)\hat{j} + y\hat{k}}{y^2 + (z-d)^2} - \frac{(z+d)\hat{j} - y\hat{k}}{y^2 + (z+d)^2} \right]$
- (D) $\left(\frac{\mu_0 I}{2\pi}\right) \left[\frac{y\hat{j} + (z-d)\hat{k}}{y^2 + (z-d)^2} + \frac{y\hat{j} - (z+d)\hat{k}}{y^2 + (z+d)^2} \right]$

Q50. [Marks: 2 | MCQ]

Electromagnetism · Magnetism

Gate 2019	MCQ	2M
-----------	-----	----

The vector potential inside a long solenoid, with n turns per unit length and carrying current I , written in cylindrical coordinates is $\vec{A}(s, \phi, z) = \frac{\mu_0 n I}{2} s \hat{\phi}$. If the term $\frac{\mu_0 n I}{2} s(\alpha \cos \phi \hat{\phi} + \beta \sin \phi \hat{s})$, where $\alpha \neq 0, \beta \neq 0$, is added to $\vec{A}(s, \phi, z)$, the magnetic field remains the same if

$$\left[\begin{array}{l} \text{Useful formulae: } \vec{\nabla} t = \frac{\partial t}{\partial s} \hat{s} + \frac{1}{s} \frac{\partial t}{\partial \phi} \hat{\phi} + \frac{\partial t}{\partial z} \hat{z} \\ \vec{\nabla} \times \vec{v} = \left(\frac{1}{s} \frac{\partial v_z}{\partial \phi} - \frac{\partial v_\phi}{\partial z} \right) \hat{s} + \left(\frac{\partial v_s}{\partial z} - \frac{\partial v_z}{\partial s} \right) \hat{\phi} \\ \quad + \frac{1}{s} \left(\frac{\partial (s v_\phi)}{\partial s} - \frac{\partial v_s}{\partial \phi} \right) \hat{z} \end{array} \right]$$

- (A) $\alpha = \beta$
 (B) $\alpha = -\beta$
 (C) $\alpha = 2\beta$
 (D) $\alpha = \frac{\beta}{2}$

Q51. [Marks: 2 | MCQ]

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

Gate 2019	MCQ	2M
-----------	-----	----

Low energy collision (s-wave scattering) of pion (π^+) with deuteron (d) results in the production of two protons ($\pi^+ + d \rightarrow p + p$). The relative orbital angular momentum (in units of \hbar) of the resulting two-proton system for this reaction is

- (A) 0
- (B) 1
- (C) 2
- (D) 3

Q52. [Marks: 2 | MCQ]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2019	MCQ	2M
-----------	-----	----

Consider the Hamiltonian $H(q, p) = \frac{\alpha p^2 q^4}{2} + \frac{\beta}{q^2}$, where α and β are parameters with appropriate dimensions, and q and p are the generalized coordinate and momentum, respectively. The corresponding Lagrangian $L(q, \dot{q})$ is

- (A) $\frac{1}{2\alpha} \frac{\dot{q}^2}{q^4} - \frac{\beta}{q^2}$
- (B) $\frac{2}{\alpha} \frac{\dot{q}^2}{q^4} + \frac{\beta}{q^2}$
- (C) $\frac{1}{\alpha} \frac{\dot{q}^2}{q^4} + \frac{\beta}{q^2}$
- (D) $-\frac{1}{2\alpha} \frac{\dot{q}^2}{q^4} + \frac{\beta}{q^2}$

Q53. [Marks: 2 | NAT]

Electronics · Basic Electronics

Gate 2019	NAT	2M
-----------	-----	----

For a given load resistance $R_L = 4.7\text{ohm}$, the power transfer efficiencies $\left(\eta = \frac{P_{\text{load}}}{P_{\text{total}}}\right)$ of a dc voltage source and a dc current source with internal resistances R_1 and R_2 , respectively, are equal. The product R_1R_2 in units of ohm^2 (rounded off to one decimal place) is ____

Q54. [Marks: 2 | NAT]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2019	NAT	2M
-----------	-----	----

The ground state electronic configuration of the rare-earth ion (Nd^{3+}) is $[\text{Pd}]4f^35s^25p^6$. Assuming LS coupling, the Landé g-factor of this ion is $\frac{8}{11}$. The effective magnetic moment in units of Bohr magneton μ_B (rounded off to two decimal places) is

Q55. [Marks: 2 | NAT]

Classical Mechanics · Basic Mechanics

Gate 2019	NAT	2M
-----------	-----	----

A projectile of mass 1 kg is launched at an angle of 30° from the horizontal direction at $t = 0$ and takes time T before hitting the ground. If its initial speed is 10 ms^{-1} , the value of the action integral for the entire flight in the units of $\text{kgm}^2 \text{ s}^{-1}$ (rounded off to one decimal place) is ____ [Take $g = 10 \text{ ms}^{-2}$]

Q56. [Marks: 2 | NAT]

Mathematical Physics · Fourier and Laplace transform

Gate 2019	NAT	2M
-----------	-----	----

Let θ be a variable in the range $-\pi \leq \theta < \pi$. Now consider a function

$$\begin{aligned} \psi(\theta) &= 1 \text{ for } -\pi/2 \leq \theta < \pi/2 \\ &= 0 \text{ otherwise.} \end{aligned}$$

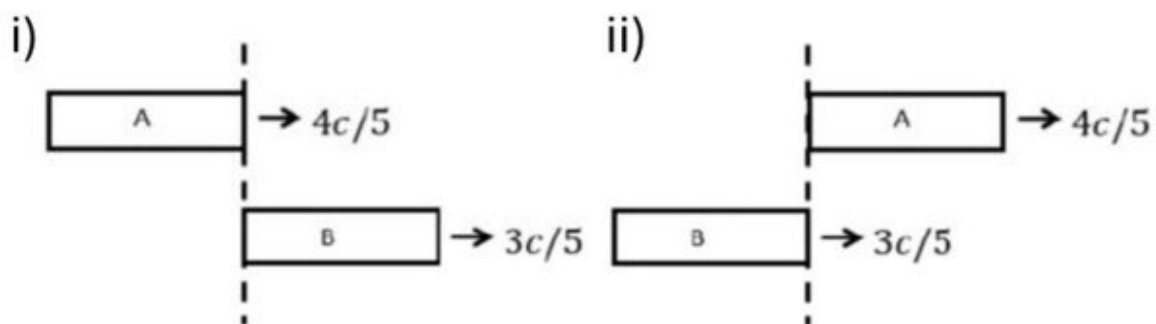
If its Fourier-series is written as $\psi(\theta) = \sum_{m=-\infty}^{\infty} C_m e^{-im\theta}$, then the value of $|C_3|^2$ (rounded off to three decimal places) is ____

Q57. [Marks: 2 | NAT]

Classical Mechanics · Special theory of relativity

Gate 2019	NAT	2M
-----------	-----	----

Two spaceships A and B, each of the same rest length L , are moving in the same direction with speeds $\frac{4c}{5}$ and $\frac{3c}{5}$, respectively, where c is the speed of light. As measured by B, the time taken by A to completely overtake B [see figure below] in units of L/c (to the nearest integer) is ____



Q58. [Marks: 2 | NAT]

Nuclear and Particle Physics · Radioactivity

Gate 2019	NAT	2M
-----------	-----	----

A radioactive element X has a half-life of 30 hours. It decays via alpha, beta and gamma emissions with the branching ratio for beta decay being 0.75. The partial half-life for beta decay in unit of hours is

Q59. [Marks: 2 | NAT]

Thermodynamics · Laws of thermodynamics

Gate 2019	NAT	2M
-----------	-----	----

In a thermally insulated container, 0.01 kg of ice at 273 K is mixed with 0.1 kg of water at 300 K. Neglecting the specific heat of the container, the change in the entropy of the system in J/K on attaining thermal equilibrium (rounded off to two decimal places) is ____ (Specific heat of water is 4.2 kJ/kg – K and the latent heat of ice is 335 kJ/kg).

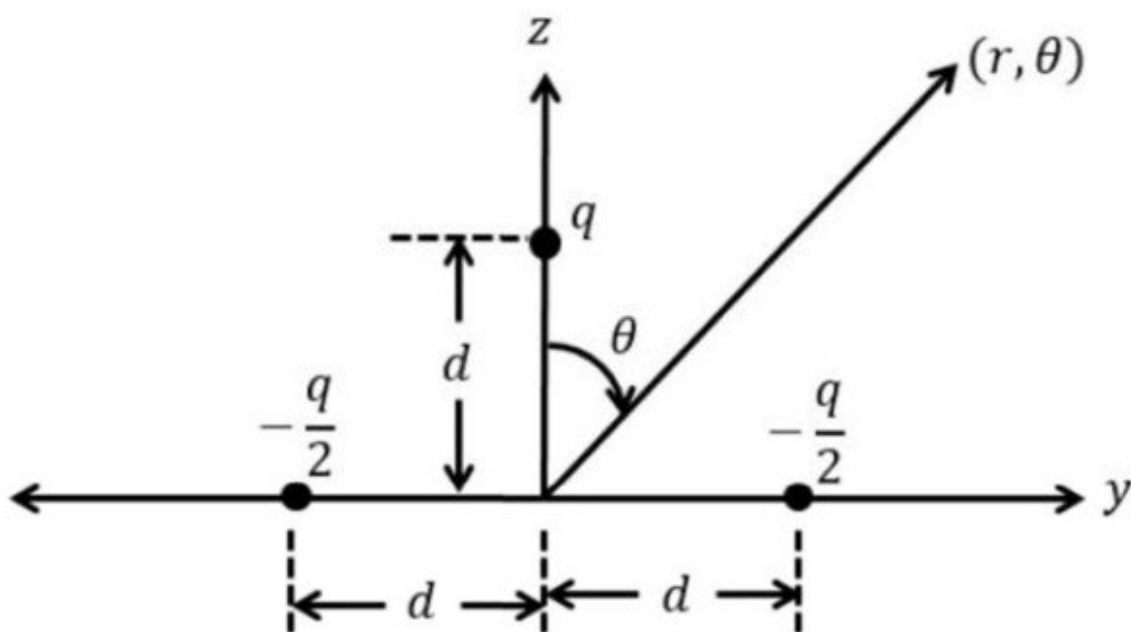
Q60. [Marks: 2 | NAT]

Electromagnetism · Electrostatics

Gate 2019	NAT	2M
-----------	-----	----

Consider a system of three charges as shown in the figure below: For $r = 10$ m; $\theta = 60$ degrees; $q = 10^{-6}$ Coulomb, and $d = 10^{-3}$ m, the electric dipole potential in volts (rounded off to three decimal places) at a point (r, θ) is

$$\left[\text{Use : } \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2} \right]$$



Q61. [Marks: 2 | NAT]

Statistical Mechanics · Microstates

Gate 2019	NAT	2M
-----------	-----	----

Consider two systems A and B each having two distinguishable particles. In both the systems, each particle can exist in states with energies 0,1,2 and 3 units with equal probability. The total energy of the combined system is 5 units. Assuming that the system A has energy 3 units and the system B has energy 2 units, the entropy of the combined system is $k_B \ln \lambda$. The value of λ is ____

Q62. [Marks: 2 | NAT]

Quantum Mechanics · Spin and Total Angular momentum

Gate 2019	NAT	2M
-----------	-----	----

Electrons with spin in the z-direction (\hat{z}) are passed through a Stern-Gerlach (SG) set up with the magnetic field at $\theta = 60^\circ$ from \hat{z} . The fraction of electrons that will emerge with their spin parallel to the magnetic field in the SG set up (rounded off to two decimal places) is ____

$$\left[\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \right]$$

Q63. [Marks: 2 | NAT]

Quantum Mechanics · Perturbation Theory

Gate 2019	NAT	2M
-----------	-----	----

The Hamiltonian of a system is $H = \begin{pmatrix} 1 & \varepsilon \\ \varepsilon & -1 \end{pmatrix}$ with $\varepsilon \ll 1$. The fourth order contribution to the ground state energy of H is $\gamma\varepsilon^4$. The value of γ (rounded off to three decimal places) is ____

Q64. [Marks: 2 | NAT]

Classical Mechanics · Special theory of relativity

Gate 2019	NAT	2M
-----------	-----	----

Two events, one on the earth and the other one on the Sun, occur simultaneously in the earth's frame. The time difference between the two events as seen by an observer in a spaceship moving with velocity $0.5c$ in the earth's frame along the line joining the earth to the Sun is Δt , where c is the speed of light. Given that light travels from the Sun to the earth in 8.3 minutes in the earth's frame, the value of $|\Delta t|$ in minutes (rounded off to two decimal places) is ____ (Take the earth's frame to be inertial and neglect the relative motion between the earth and the sun)

Q65. [Marks: 2 | NAT]

Solid State Physics · Tight binding model

Gate 2019	NAT	2M
-----------	-----	----

In a certain two-dimensional lattice, the energy dispersion of the electrons is

$$\varepsilon(\vec{k}) = -2t \left[\cos k_x a + 2 \cos \frac{1}{2} k_x a \cos \frac{\sqrt{3}}{2} k_y a \right]$$

where $\vec{k} = (k_x, k_y)$ denotes the wave vector, a is the lattice constant and t is a constant in units of eV. In this lattice the effective mass tensor m_{ij} of electrons calculated at the center of the Brillouin zone has the form $m_{ij} = \frac{\hbar^2}{ta^2} \begin{pmatrix} \alpha & 0 \\ 0 & \alpha \end{pmatrix}$. The value of α (rounded off to three decimal places) 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	Reasoning	MCQ	1	C
Q3	General Aptitude	Geometry	MCQ	1	C
Q4	General Aptitude	Reasoning	MCQ	1	C
Q5	General Aptitude	English	MCQ	1	A
Q6	General Aptitude	Reasoning	MCQ	2	C
Q7	General Aptitude	Mathematical Analysis	MCQ	2	A
Q8	General Aptitude	Reasoning	MCQ	2	C
Q9	General Aptitude	Reasoning	MCQ	2	B
Q10	General Aptitude	Reasoning	MCQ	2	D
Q11	Solid State Physics	Superconductivity	MCQ	1	A
Q12	Nuclear and Particle Phy...	Particle Physics	MCQ	1	C
Q13	Electronics	OPAMP	MCQ	1	C
Q14	Mathematical Physics	Special functions	MCQ	1	B
Q15	Thermodynamics	Kinetic theory of gases	MCQ	1	A
Q16	Quantum Mechanics	Perturbation Theory	MCQ	1	C
Q17	Quantum Mechanics	Quantum Statistical Mechanics	MCQ	1	A
Q18	Mathematical Physics	Matrices	MCQ	1	B
Q19	Quantum Mechanics	Spin and Total Angular momentum	MCQ	1	D
Q20	Classical Mechanics	Canonical Transformation and Poiss...	MCQ	1	B
Q21	Solid State Physics	Lattice vibration	MCQ	1	B
Q22	Mathematical Physics	Complex Analysis	MCQ	1	C
Q23	Nuclear and Particle Phy...	Particle Physics	MCQ	1	C
Q24	Optics	Polarization	MCQ	1	D
Q25	Nuclear and Particle Phy...	Shell Model	MCQ	1	A
Q26	Electromagnetism	Electrostatics	MCQ	1	B
Q27	Solid State Physics	Lattice vibration	NAT	1	1.07 to 1.11
Q28	Statistical Mechanics	Quantum Statistical Mechanics	NAT	1	1 to 1
Q29	Electromagnetism	Electrodynamics	NAT	1	6.26 to 6.30
Q30	Electromagnetism	EM Waves	NAT	1	0.8 to 0.8
Q31	Quantum Mechanics	Quantum Harmonic Oscillator	NAT	1	2.5 to 2.5
Q32	Classical Mechanics	Lagrangian and Hamiltonian	NAT	1	3 to 3
Q33	Statistical Mechanics	Quantum Statistical Mechanics	NAT	1	126 to 1266
Q34	Quantum Mechanics	Basics Quantum Mechanics	NAT	1	0.6 to 0.6
Q35	Solid State Physics	Superconductivity	NAT	1	0.244 to 0.248
Q36	Electronics	Logic Gates	MCQ	2	D

Answer Key

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

Q.No	Subject	Topic	Type	Marks	Answer
Q37	Mathematical Physics	Complex Analysis	MCQ	2	A
Q38	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	B
Q39	Electromagnetism	Magnetism	MCQ	2	C
Q40	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	D
Q41	Electronics	AD/DA coversion	MCQ	2	C
Q42	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	C
Q43	Solid State Physics	Tight binding model	MCQ	2	D
Q44	Quantum Mechanics	Potential Well	MCQ	2	A
Q45	Atomic and Molecular Ph...	Effects in atomic physics	MCQ	2	A
Q46	Electronics	Logic Gates	MCQ	2	A
Q47	Optics	Polarization	MCQ	2	C
Q48	Classical Mechanics	Phase diagram	MCQ	2	B
Q49	Solid State Physics	Superconductivity	MCQ	2	B
Q50	Electromagnetism	Magnetism	MCQ	2	D
Q51	Nuclear and Particle Phy...	Nuclear Force, deuteron problem an...	MCQ	2	B
Q52	Classical Mechanics	Lagrangian and Hamiltonian	MCQ	2	A
Q53	Electronics	Basic Electronics	NAT	2	22.0 to 22.2
Q54	Atomic and Molecular Ph...	Effects in atomic physics	NAT	2	3.61 to 3.63
Q55	Classical Mechanics	Basic Mechanics	NAT	2	33.2 to 33.4
Q56	Mathematical Physics	Fourier and Laplace transform	NAT	2	0.010 to 0.013
Q57	Classical Mechanics	Special theory of relativity	NAT	2	5 to 5
Q58	Nuclear and Particle Phy...	Radioactivity	NAT	2	40 to 40
Q59	Thermodynamics	Laws of thermodynamics	NAT	2	1.02 to 1.04
Q60	Electromagnetism	Electrostatics	NAT	2	0.044 to 0.046
Q61	Statistical Mechanics	Microstates	NAT	2	12 to 12
Q62	Quantum Mechanics	Spin and Total Angular momentum	NAT	2	0.75 to 0.75
Q63	Quantum Mechanics	Perturbation Theory	NAT	2	0.125 to 0.125
Q64	Classical Mechanics	Special theory of relativity	NAT	2	4.77 to 4.81
Q65	Solid State Physics	Tight binding model	NAT	2	0.333 to 0.333