

# PhysicsByAaryan

CSIR NET · GATE · JEST · BARC – Physics

## GATE Physics 2021 — Full Question Paper

Previous Year Questions with Official Answer Key

### Inside this PDF

- Every GATE Physics (PH) 2021 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 2021	MCQ	1M
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- (i) Arun and Aparna are here.
- (ii) Arun and Aparna is here.
- (iii) Arun's families is here.
- (iv) Arun's family is here.

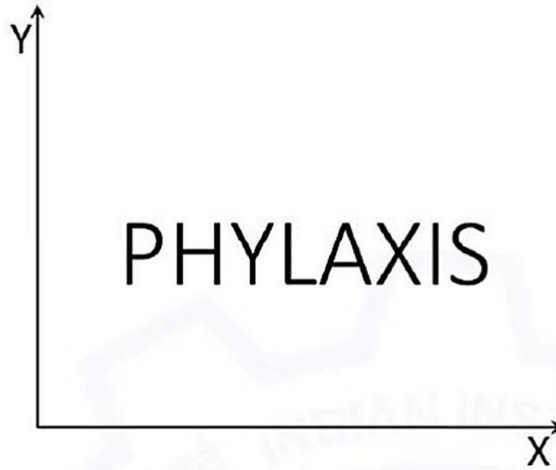
Which of the above sentences are grammatically CORRECT?

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

Q2. [Marks: 1 | MCQ]

General Aptitude · Reasoning

Gate 2021	MCQ	1M
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The mirror image of the above text about the  $x$ -axis is

- (A) PHYLAXIS
- (B) PHYLAXIS
- (C) PHYLAXIS
- (D) PHYLAXIS

Q3. [Marks: 1 | MCQ]

General Aptitude · Mathematical Analysis

Gate 2021	MCQ	1M
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Two identical cube shaped dice each with faces numbered 1 to 6 are rolled simultaneously. The probability that an even number is rolled out on each dice is:

- (A)  $\frac{1}{36}$
- (B)  $\frac{1}{12}$
- (C)  $\frac{1}{8}$
- (D)  $\frac{1}{4}$

Q4. [Marks: 1 | MCQ]

General Aptitude · Reasoning

Gate 2021	MCQ	1M
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$\oplus$  and  $\odot$  are two operators on numbers  $p$  and  $q$  such that  $p \odot q = p - q$ , and  $p \oplus q = p \times q$  Then,  
 $(9 \odot (6 \oplus 7)) \odot (7 \oplus (6 \odot 5)) =$

- (A) 40
- (B) -26
- (C) -33
- (D) -40

Q5. [Marks: 1 | MCQ]

General Aptitude · Mathematical Analysis

Gate 2021	MCQ	1M
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Four persons  $P, Q, R$  and  $S$  are to be seated in a row.  $R$  should not be seated at the second position from the left end of the row. The number of distinct seating arrangements possible is:

- (A) 6
- (B) 9
- (C) 18
- (D) 24

Q6. [Marks: 2 | MCQ]

General Aptitude · Geometry

Gate 2021	MCQ	2M
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On a planar field, you travelled 3 units East from a point  $O$ . Next you travelled 4 units South to arrive at point  $P$ . Then you travelled from  $P$  in the North-East direction such that you arrive at a point that is 6 units East of point  $O$ . Next, you travelled in the North-West direction, so that you arrive at point  $Q$  that is 8 units North of point  $P$ .

The distance of point  $Q$  to point  $O$ , in the same units, should be \_\_\_\_

- (A) 3
- (B) 4
- (C) 5
- (D) 6

Q7. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2021	MCQ	2M
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The author said, "Musicians rehearse before their concerts. Actors rehearse their roles before the opening of a new play. On the other hand, I find it strange that many public speakers think they can just walk on to the stage and start speaking. In my opinion, it is no less important for public speakers to rehearse their talks."

Based on the above passage, which one of the following is TRUE?

- (A) The author is of the opinion that rehearsing is important for musicians, actors and public speakers.
- (B) The author is of the opinion that rehearsing is less important for public speakers than for musicians and actors.
- (C) The author is of the opinion that rehearsing is more important only for musicians than public speakers.
- (D) The author is of the opinion that rehearsal is more important for actors than musicians.

Q8. [Marks: 2 | MCQ]

General Aptitude · Reasoning

Gate 2021	MCQ	2M
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1. Some football players play cricket.
2. All cricket players play hockey.

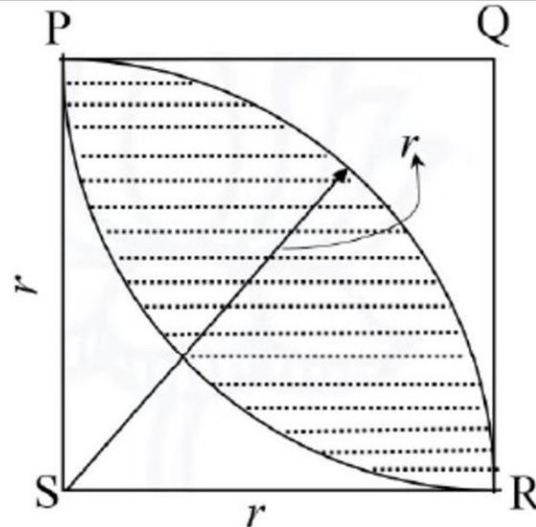
Among the options given below, the statement that logically follows from the two statements 1 and 2 above, is:

- (A) No football player plays hockey.
  - (B) Some football players play hockey.
  - (C) All football players play hockey.
  - (D) All hockey players play football.
-

Q9. [Marks: 2 | MCQ]

General Aptitude · Geometry

Gate 2021	MCQ	2M
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In the figure shown above, PQRS is a square. The shaded portion is formed by the intersection of sectors of circles with radius equal to the side of the square and centers at  $S$  and  $Q$ .

The probability that any point picked randomly within the square falls in the shaded area is \_\_\_\_

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

Q10. [Marks: 2 | MCQ]

General Aptitude · Geometry

Gate 2021	MCQ	2M
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In an equilateral triangle PQR, side PQ is divided into four equal parts, side QR is divided into six equal parts and side PR is divided into eight equal parts. The length of each subdivided part in cm is an integer.

The minimum area of the triangle PQR possible, in  $\text{cm}^2$ , is

- (A) 18
- (B) 24
- (C)  $48\sqrt{3}$
- (D)  $144\sqrt{3}$

Q11. [Marks: 1 | MCQ]

Solid State Physics · Dielectric Properties of solid

Gate 2021

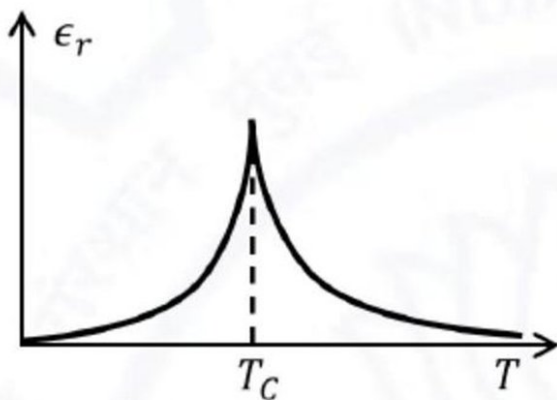
MCQ

1M

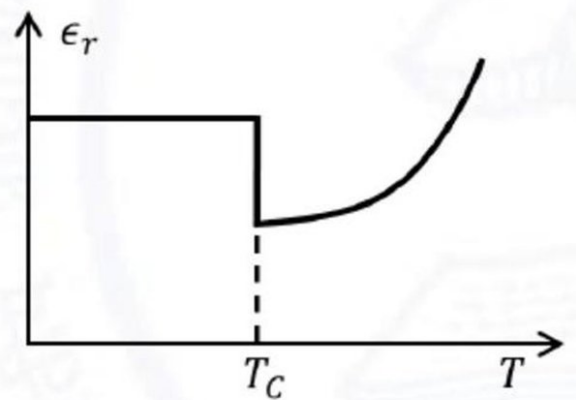
Choose the graph that best describes the variation of dielectric constant ( $\epsilon_r$ ) with temperature ( $T$ ) in a ferroelectric material.

( $T_C$  is the Curie temperature)

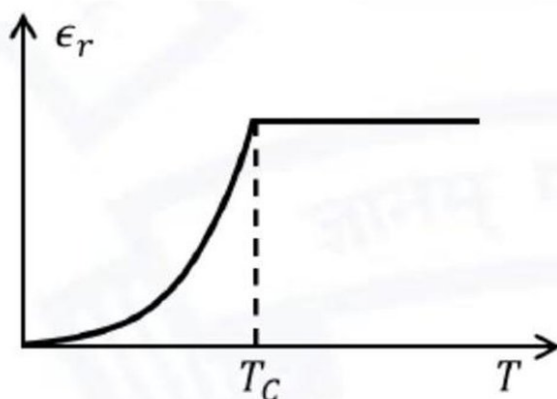
(A)



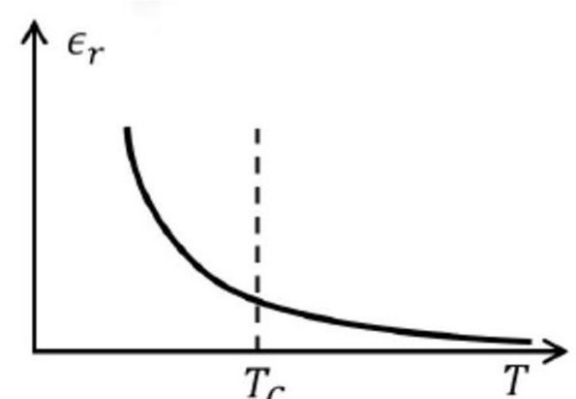
(B)



(C)



(D)



Q12. [Marks: 1 | MCQ]

Electromagnetism · EM Waves

Gate 2021	MCQ	1M
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A matter wave is represented by the wave function  $\Psi(x, y, z, t) = Ae^{i(4x+3y+5z-10\pi t)}$  where  $A$  is a constant. The unit vector representing the direction of propagation of this matter wave is

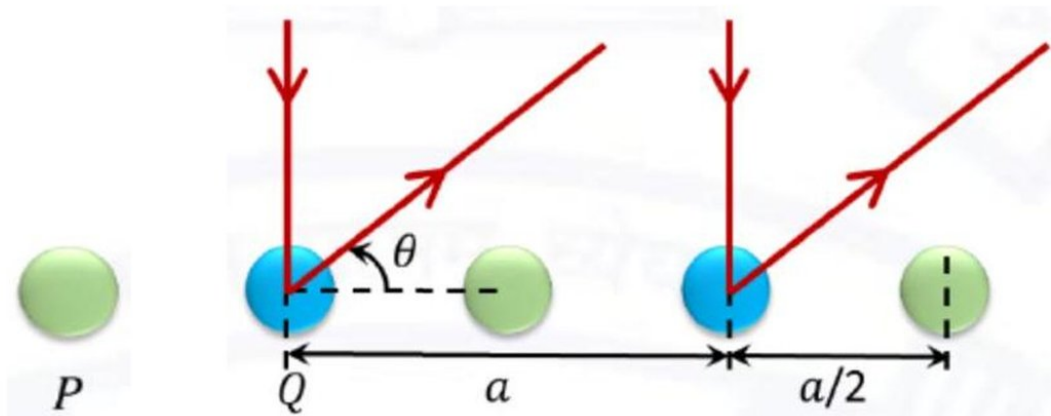
- (A)  $\frac{4}{5\sqrt{2}}\hat{x} + \frac{3}{5\sqrt{2}}\hat{y} + \frac{1}{\sqrt{2}}\hat{z}$
- (B)  $\frac{3}{5\sqrt{2}}\hat{x} + \frac{4}{5\sqrt{2}}\hat{y} + \frac{1}{5\sqrt{2}}\hat{z}$
- (C)  $\frac{1}{5\sqrt{2}}\hat{x} + \frac{3}{5\sqrt{2}}\hat{y} + \frac{1}{\sqrt{2}}\hat{z}$
- (D)  $\frac{1}{5\sqrt{2}}\hat{x} + \frac{4}{5\sqrt{2}}\hat{y} + \frac{3}{5\sqrt{2}}\hat{z}$

Q13. [Marks: 1 | MCQ]

Solid State Physics · Xray diffraction

Gate 2021	MCQ	1M
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As shown in the figure, X-ray diffraction pattern is obtained from a diatomic chain of atoms  $P$  and  $Q$ . The diffraction condition is given by  $a \cos \theta = n \lambda$ , where  $n$  is the order of the diffraction peak. Here,  $a$  is the lattice constant and  $\lambda$  is the wavelength of the X-rays. Assume that atomic form factors and resolution of the instrument do not depend on  $\theta$ . Then, the intensity of the diffraction peaks is



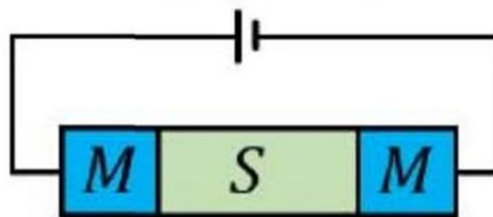
- (A) lower for even values of  $n$ , when compared to odd values of  $n$
- (B) lower for odd values of  $n$ , when compared to even values of  $n$
- (C) zero for odd values of  $n$
- (D) zero for even values of  $n$

Q14. [Marks: 1 | MCQ]

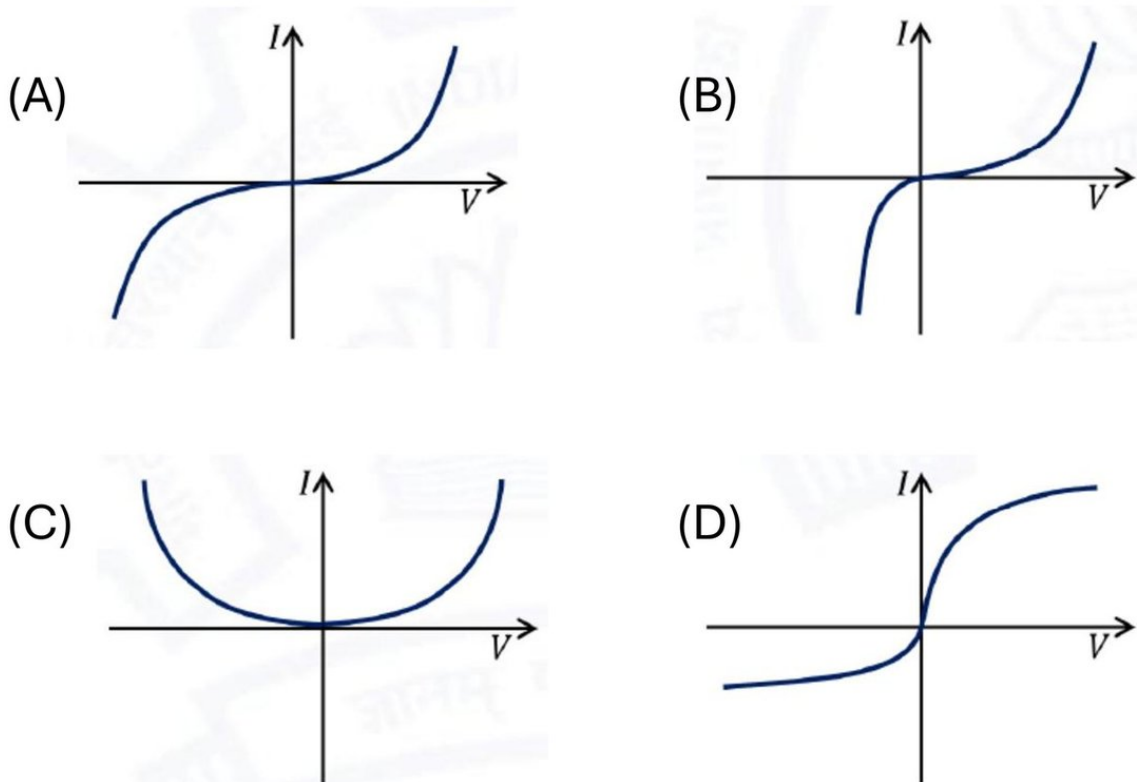
Solid State Physics · Semiconductor Physics

Gate 2021	MCQ	1M
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As shown in the figure, two metal-semiconductor junctions are formed between an n-type semiconductor  $S$  and metal  $M$ . The work functions of  $S$  and  $M$  are  $\phi_S$  and  $\phi_M$ , respectively with  $\phi_M > \phi_S$ .



The  $I - V$  characteristics (on linear scale) of the junctions is best represented by



Q15. [Marks: 1 | MCQ]

Electromagnetism · Electrodynamics

Gate 2021	MCQ	1M
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Consider a tiny current loop driven by a sinusoidal alternating current. If the surface integral of its time-averaged Poynting vector is constant, then the magnitude of the time-averaged magnetic field intensity, at any arbitrary position,  $\vec{r}$ , is proportional to

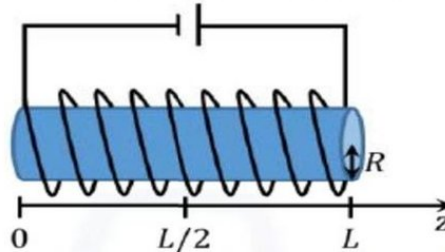
- (A)  $\frac{1}{r^3}$
- (B)  $\frac{1}{r^2}$
- (C)  $\frac{1}{r}$
- (D)  $r$

Q16. [Marks: 1 | MCQ]

Electromagnetism · Magnetism

Gate 2021	MCQ	1M
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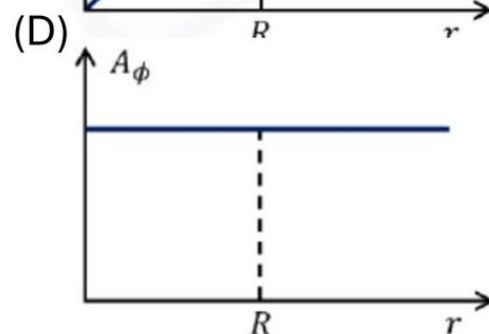
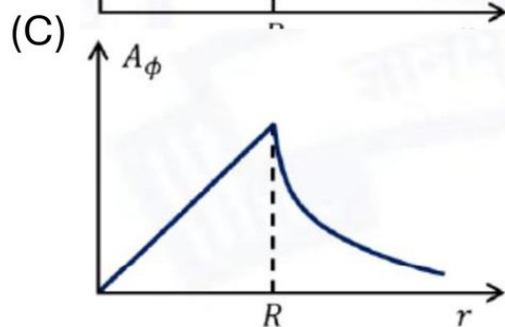
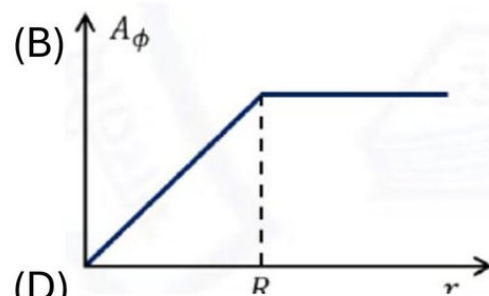
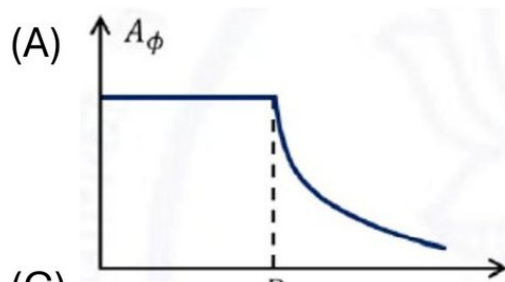
Consider a solenoid of length  $L$  and radius  $R$ , where  $R \ll L$ . A steady-current flows through the solenoid. The magnetic field is uniform inside the solenoid and zero outside.



Among the given options, choose the one that best represents the variation in the magnitude of the vector potential,  $(0, A_\phi, 0)$  at  $z = L/2$ , as a function of the radial distance ( $r$ ) in cylindrical coordinates.

Useful information: The curl of a vector  $\vec{F}$ , in cylindrical coordinates is

$$\vec{\nabla} \times \vec{F}(r, \phi, z) = \hat{r} \left[ \frac{1}{r} \frac{\partial F_z}{\partial \phi} - \frac{\partial F_\phi}{\partial z} \right] + \hat{\phi} \left[ \frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r} \right] + \hat{z} \frac{1}{r} \left[ \frac{\partial(rF_\phi)}{\partial r} - \frac{\partial F_r}{\partial \phi} \right]$$



Q17. [Marks: 1 | MCQ]

Nuclear and Particle Physics · Radioactivity

Gate 2021	MCQ	1M
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Assume that  $^{13}\text{N}$  ( $Z = 7$ ) undergoes first forbidden  $\beta^+$  decay from its ground state with spin-parity  $J_i^\pi$ , to a final state  $J_f^\pi$ . The possible values for  $J_i^\pi$  and  $J_f^\pi$ , respectively, are

(A)  $\frac{1^-}{2}$ ,  $\frac{5^+}{2}$

(B)  $\frac{1^+}{2}$ ,  $\frac{5^+}{2}$

(C)  $\frac{1^-}{2}$ ,  $\frac{1^-}{2}$

(D)  $\frac{1^+}{2}$ ,  $\frac{1^-}{2}$

Q18. [Marks: 1 | MCQ]

Nuclear and Particle Physics · Radioactivity

Gate 2021	MCQ	1M
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In an experiment, it is seen that an electric-dipole ( $E1$ ) transition can connect an initial nuclear state of spin-parity  $J_i^\pi = 2^+$  to a final state  $J_f^\pi$ . All possible values of  $J_f^\pi$  are

- (A)  $1^+, 2^+$
- (B)  $1^+, 2^+, 3^+$
- (C)  $1^-, 2^-$
- (D)  $1^-, 2^-, 3^-$

Q19. [Marks: 1 | MCQ]

Solid State Physics · Semiconductor Physics

Gate 2021	MCQ	1M
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Choose the correct statement from the following.

- (A) Silicon is a direct band gap semiconductor.
  - (B) Conductivity of metals decreases with increase in temperature.
  - (C) Conductivity of semiconductors decreases with increase in temperature.
  - (D) Gallium Arsenide is an indirect band gap semiconductor.
-

Q20. [Marks: 1 | MSQ]

Solid State Physics · Tight binding model

Gate 2021	MSQ	1M
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A two-dimensional square lattice has lattice constant  $a$ .  $\mathbf{k}$  represents the wavevector in reciprocal space. The coordinates  $(k_x, k_y)$  of reciprocal space where band gap(s) can occur, are

(A)  $(0,0)$

(B)  $\left(\pm \frac{\pi}{a}, \pm \frac{\pi}{a}\right)$

(C)  $\left(\pm \frac{\pi}{a}, \pm \frac{\pi}{1.3a}\right)$

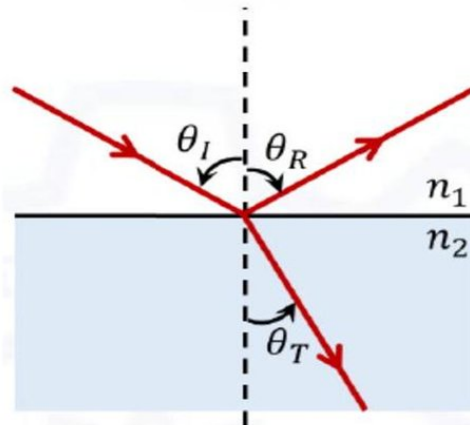
(D)  $\left(\pm \frac{\pi}{3a}, \pm \frac{\pi}{a}\right)$

Q21. [Marks: 1 | MSQ]

Optics · Polarization

Gate 2021	MSQ	1M
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As shown in the figure, an electromagnetic wave with intensity  $I_I$  is incident at the interface of two media having refractive indices  $n_1 = 1$  and  $n_2 = \sqrt{3}$ . The wave is reflected with intensity  $I_R$  and transmitted with intensity  $I_T$ . Permeability of each medium is the same. (Reflection coefficient  $R = I_R/I_I$  and Transmission coefficient  $T = I_T/I_I$



Choose the correct statement(s).

- (A)  $R = 0$  if  $\theta_I = 0^\circ$  and polarization of incident light is parallel to the plane of incidence.
- (B)  $T = 1$  if  $\theta_I = 60^\circ$  and polarization of incident light is parallel to the plane of incidence.
- (C)  $R = 0$  if  $\theta_I = 60^\circ$  and polarization of incident light is perpendicular to the plane of incidence.
- (D)  $T = 1$  if  $\theta_I = 60^\circ$  and polarization of incident light is perpendicular to the plane of incidence.

Q22. [Marks: 1 | MSQ]

Electromagnetism · Magnetism in matter

Gate 2021	MSQ	1M
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A material is placed in a magnetic field intensity  $\mathbf{H}$ . As a result, bound current density  $J_b$  is induced and magnetization of the material is  $\mathbf{M}$ . The magnetic flux density is  $\mathbf{B}$ . Choose the correct option(s) valid at the surface of the material.

- (A)  $\nabla \cdot \mathbf{M} = 0$
- (B)  $\nabla \cdot \mathbf{B} = 0$
- (C)  $\nabla \cdot \mathbf{H} = 0$
- (D)  $\nabla \cdot \mathbf{J}_b = 0$

Q23. [Marks: 1 | MSQ]

Statistical Mechanics · Quantum Statistical Mechanics

Gate 2021	MSQ	1M
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For a finite system of Fermions where the density of states increases with energy, the chemical potential

- (A) decreases with temperature
- (B) increases with temperature
- (C) does not vary with temperature
- (D) corresponds to the energy where the occupation probability is 0.5

Q24. [Marks: 1 | MSQ]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2021	MSQ	1M
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Among the term symbols  ${}^4S_1$ ,  ${}^2D_{7/2}$ ,  ${}^3S_1$  and  ${}^2D_{5/2}$  choose the option(s) possible in the  $LS$  coupling notation.

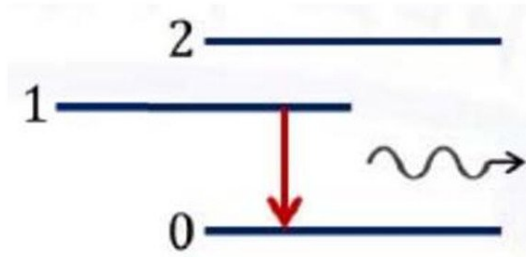
- (A)  ${}^4S_1$
- (B)  ${}^2D_{7/2}$
- (C)  ${}^3S_1$
- (D)  ${}^2D_{5/2}$

Q25. [Marks: 1 | MSQ]

Atomic and Molecular Physics · Lasers

Gate 2021	MSQ	1M
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To sustain lasing action in a three-level laser as shown in the figure, necessary condition(s) is(are)



- (A) lifetime of the energy level 1 should be greater than that of energy level 2
- (B) population of the particles in level 1 should be greater than that of level 0
- (C) lifetime of the energy level 2 should be greater than that of energy level 0
- (D) population of the particles in level 2 should be greater than that of level 1

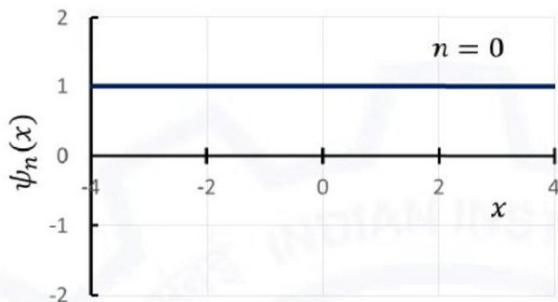
Q26. [Marks: 1 | MSQ]

Mathematical Physics · Special functions

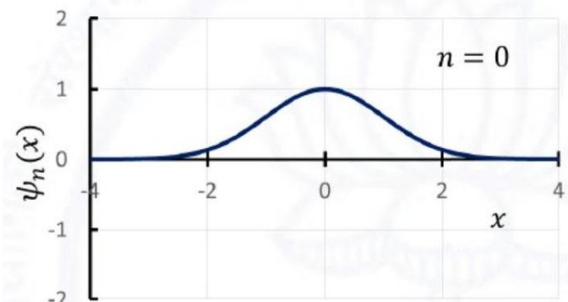
Gate 2021	MSQ	1M
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If  $y_n(x)$  is a solution of the differential equation  $y'' - 2xy' + 2ny = 0$  where  $n$  is an integer and the prime ( ' ) denotes differentiation with respect to  $x$ , then acceptable plot(s) of  $\psi_n(x) = e^{-x^2/2}y_n(x)$ , is(are)

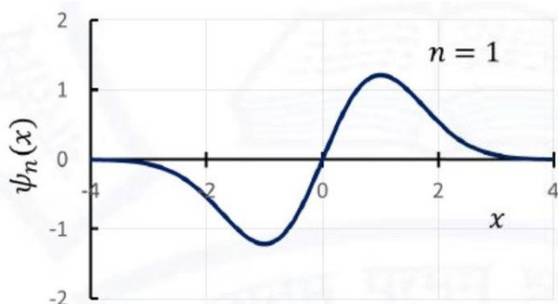
(A)



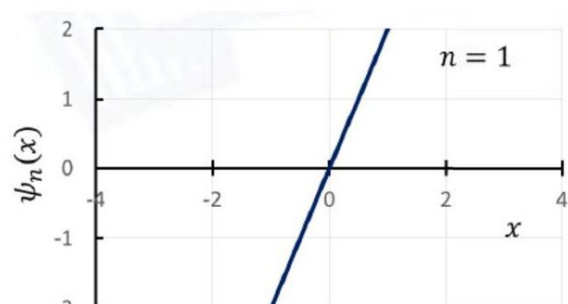
(B)



(C)



(D)



Q27. [Marks: 1 | NAT]

Solid State Physics · Semiconductor Physics

Gate 2021	NAT	1M
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The donor concentration in a sample of  $n$ -type silicon is increased by a factor of 100 . Assuming the sample to be non-degenerate, the shift in the Fermi level (in meV ) at 300 K (rounded off to the nearest integer) is \_\_\_\_ .

(Given:  $k_B T = 25 \text{ meV}$  at 300 K )

Q28. [Marks: 1 | NAT]

Classical Mechanics · Special theory of relativity

Gate 2021	NAT	1M
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Two observers  $O$  and  $O'$  observe two events  $P$  and  $Q$ . The observers have a constant relative speed of  $0.5 c$  . In the units, where the speed of light,  $c$  , is taken as unity, the observer  $O$  obtained the following coordinates:

Event  $P$ :  $x = 5, y = 3, z = 5, t = 3$

Event  $Q$ :  $x = 5, y = 1, z = 3, t = 5$

The length of the space-time interval between these two events, as measured by  $O'$ , is  $L$ . The value of  $|L|$  (in integer) is \_\_\_\_ .

Q29. [Marks: 1 | NAT]

Statistical Mechanics · Quantum Statistical Mechanics

Gate 2021	NAT	1M
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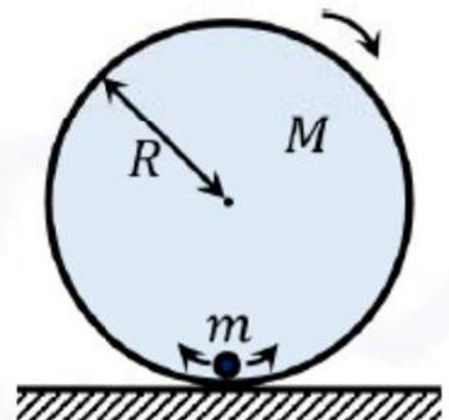
A light source having its intensity peak at the wavelength 289.8 nm is calibrated as 10,000 K which is the temperature of an equivalent black body radiation. Considering the same calibration, the temperature of light source (in K) having its intensity peak at the wavelength 579.6 nm (rounded off to the nearest integer) is\_\_\_\_\_.

Q30. [Marks: 1 | NAT]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2021	NAT	1M
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A hoop of mass  $M$  and radius  $R$  rolls without slipping along a straight line on a horizontal surface as shown in the figure. A point mass  $m$  slides without friction along the inner surface of the hoop, performing small oscillations about the mean position. The number of degrees of freedom of the system (in integer) is \_\_\_\_ .



Q31. [Marks: 1 | NAT]

Statistical Mechanics · Microstates

Gate 2021	NAT	1M
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Three non-interacting bosonic particles of mass  $m$  each, are in a one-dimensional infinite potential well of width  $a$ . The energy of the third excited state of the system is  $x \times \frac{\hbar^2 \pi^2}{ma^2}$ . The value of  $x$  (in integer) is\_\_

Q32. [Marks: 1 | NAT]

Atomic and Molecular Physics · Molecular Physics

Gate 2021	NAT	1M
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The spacing between two consecutive S-branch lines of the rotational Raman spectra of hydrogen gas is  $243.2 \text{ cm}^{-1}$ . After excitation with a laser of wavelength  $514.5 \text{ nm}$ , the Stoke's line appeared at  $17611.4 \text{ cm}^{-1}$  for a particular energy level. The wavenumber (rounded off to the nearest integer), in  $\text{cm}^{-1}$ , at which Stoke's line will appear for the next higher energy level is \_\_\_\_ .

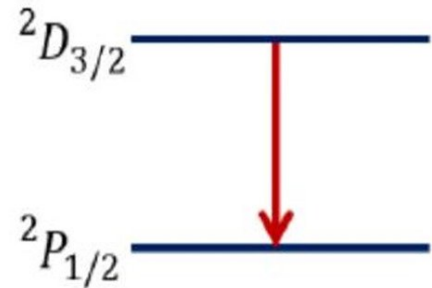
Q33. [Marks: 1 | NAT]

Atomic and Molecular Physics · Lasers

Gate 2021	NAT	1M
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The transition line, as shown in the figure, arises between

${}^2D_{3/2}$  and  ${}^2P_{1/2}$  states without any external magnetic field.



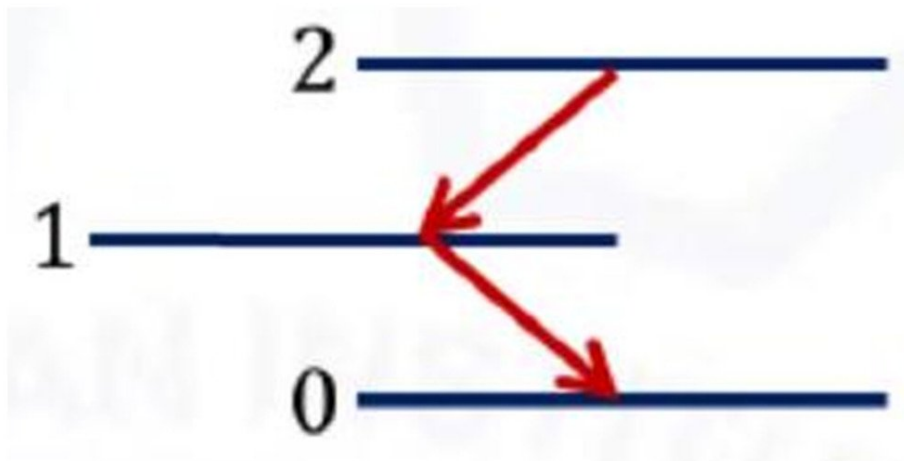
The number of lines that will appear in the presence of a weak magnetic field (in integer) is \_\_\_\_.

Q34. [Marks: 1 | NAT]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2021	NAT	1M
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Consider the atomic system as shown in the figure, where the Einstein  $A$  coefficients for spontaneous emission for the levels are  $A_{2 \rightarrow 1} = 2 \times 10^7 \text{ s}^{-1}$  and  $A_{1 \rightarrow 0} = 10^8 \text{ s}^{-1}$ . If  $10^{14}$  atoms  $/\text{cm}^3$  are excited from level 0 to level 2 and a steady state population in level 2 is achieved, then the steady state population in level 2 is achieved, then the steady state population at level 1 will be  $x \times 10^{13} \text{ cm}^{-3}$ . The value of  $x$  (in integer) is \_\_\_\_.



Q35. [Marks: 1 | NAT]

Classical Mechanics · Canonical Transformation and Poisson bracket

Gate 2021	NAT	1M
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If  $\vec{a}$  and  $\vec{b}$  are constant vectors,  $\vec{r}$  and  $\vec{p}$  are generalized positions and conjugate momenta, respectively, then for the transformation  $Q = \vec{a} \cdot \vec{p}$  and  $P = \vec{b} \cdot \vec{r}$  to be canonical, the value of  $\vec{a} \cdot \vec{b}$  (in integer) is \_\_\_\_ .

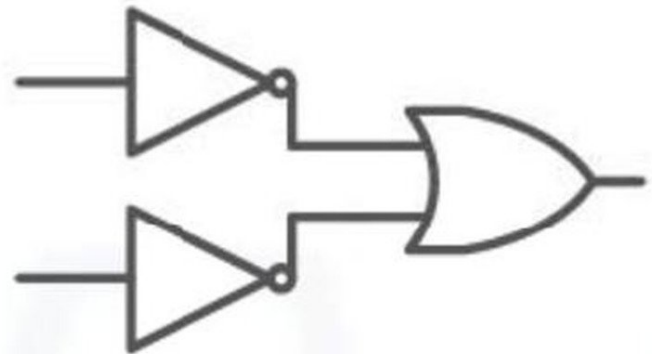
Q36. [Marks: 2 | MCQ]

Electronics · Logic Gates

Gate 2021	MCQ	2M
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The above combination of logic gates represents the operation

- (A) OR
- (B) NAND
- (C) AND
- (D) NOR



Q37. [Marks: 2 | MCQ]

Solid State Physics · Semiconductor Physics

Gate 2021	MCQ	2M
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In a semiconductor, the ratio of the effective mass of hole to electron is 2:11 and the ratio of average relaxation time for hole to electron is 1: 2. The ratio of the mobility of the hole to electron is

- (A) 4:9
- (B) 4:11
- (C) 9:4
- (D) 11:4

Q38. [Marks: 2 | MCQ]

Quantum Mechanics · Spin and Total Angular momentum

Gate 2021	MCQ	2M
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Consider a spin  $S = \hbar/2$  particle in the state  $|\phi\rangle = \frac{1}{3} \begin{bmatrix} 2 + i \\ 2 \end{bmatrix}$ . The probability that a measurement finds the state with  $S_x = +\hbar/2$  is

- (A) 5/18
- (B) 11/18
- (C) 15/18
- (D) 17/18

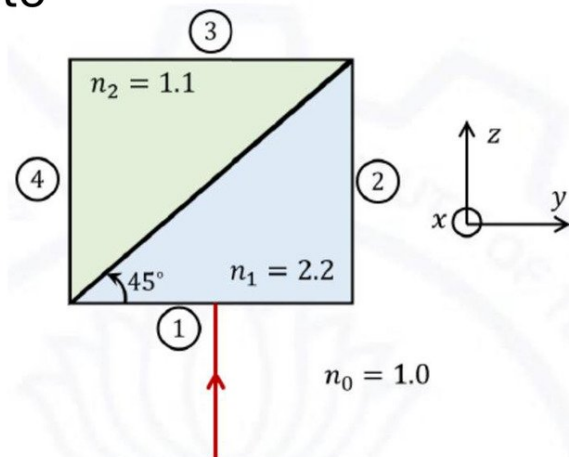
Q39. [Marks: 2 | MCQ]

Electromagnetism · EM Waves

Gate 2021	MCQ	2M
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An electromagnetic wave having electric field  $E = 8\cos(kz - \omega t)\hat{y} \text{ V cm}^{-1}$  is incident at  $90^\circ$  (normal incidence) on a square slab from vacuum (with refractive index  $n_0 = 1.0$ ) as shown in the figure. The slab is composed of two different materials with refractive indices  $n_1$  and  $n_2$ . Assume that the permeability of each medium is the same. After passing through the slab for the first time, the electric field amplitude, in  $\text{Vcm}^{-1}$ , of the electromagnetic wave, which emerges from the slab in region 2, is closest to

- (A)  $\frac{11}{1.6}$   
 (B)  $\frac{11}{3.2}$   
 (C)  $\frac{11}{13.8}$   
 (D)  $\frac{11}{25.6}$

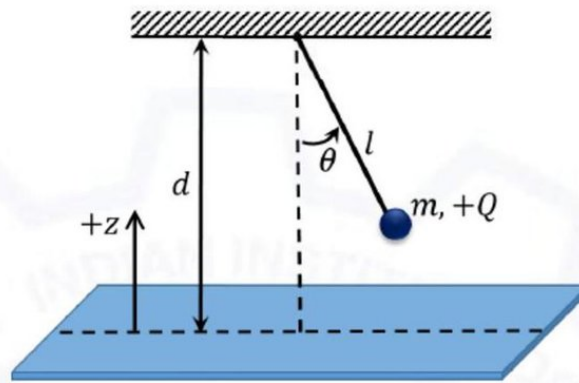


Q40. [Marks: 2 | MCQ]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2021	MCQ	2M
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Consider a point charge  $+Q$  of mass  $m$  suspended by a massless, inextensible string of length  $l$  in free space (permittivity  $\epsilon_0$ ) as shown in the figure. It is placed at a height  $d$  ( $d > l$ ) over an infinitely large, grounded conducting plane. The gravitational potential energy is assumed to be zero at the position of the conducting plane and is positive above the plane.



If  $\theta$  represents the angular position and  $p_\theta$  its corresponding canonical momentum, then the correct Hamiltonian of the system is

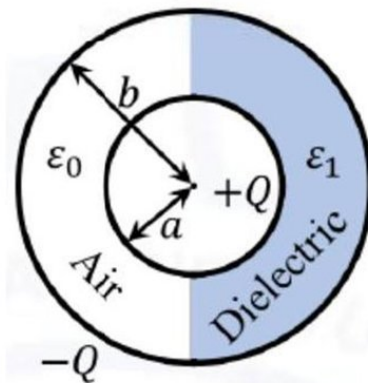
- (A)  $\frac{p_\theta^2}{2ml^2} - \frac{Q^2}{16\pi\epsilon_0(d-l\cos\theta)} - mg(d-l\cos\theta)$
- (B)  $\frac{p_\theta^2}{2ml^2} - \frac{Q^2}{8\pi\epsilon_0(d-l\cos\theta)} + mg(d-l\cos\theta)$
- (C)  $\frac{p_\theta^2}{2ml^2} - \frac{Q^2}{8\pi\epsilon_0(d-l\cos\theta)} - mg(d-l\cos\theta)$
- (D)  $\frac{p_\theta^2}{2ml^2} - \frac{Q^2}{16\pi\epsilon_0(d-l\cos\theta)} + mg(d-l\cos\theta)$

Q41. [Marks: 2 | MCQ]

Electromagnetism · Electric field in matter

Gate 2021	MCQ	2M
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Consider two concentric conducting spherical shells as shown in the figure. The inner shell has a radius  $a$  and carries a charge  $+Q$ . The outer shell has a radius  $b$  and carries a charge  $-Q$ . The empty space between them is half-filled by a hemispherical shell of a dielectric having permittivity  $\epsilon_1$ . The remaining space between the shells is filled with air having the permittivity  $\epsilon_0$ .

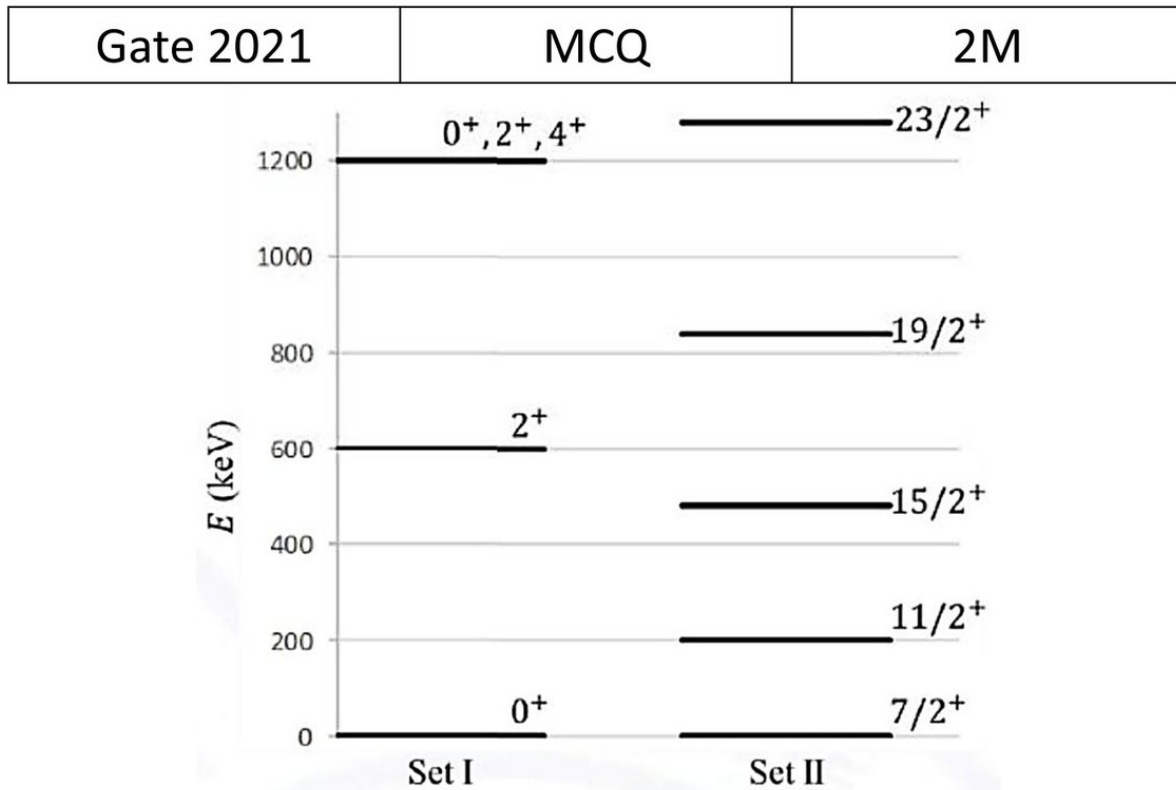


The electric field at a radial distance  $r$  from the center and between the shells ( $a < r < b$ ) is

- (A)  $\frac{Q}{2\pi(\epsilon_0 + \epsilon_1)} \frac{\hat{r}}{r^2}$  everywhere
- (B)  $\frac{Q}{4\pi\epsilon_0} \frac{\hat{r}}{r^2}$  on the air side and  $\frac{Q}{4\pi\epsilon_1} \frac{\hat{r}}{r^2}$  on the dielectric side
- (C)  $\frac{Q}{2\pi\epsilon_0} \frac{\hat{r}}{r^2}$  on the air side and  $\frac{Q}{2\pi\epsilon_1} \frac{\hat{r}}{r^2}$  on the dielectric side
- (D)  $\frac{Q}{4\pi(\epsilon_0 + \epsilon_1)} \frac{\hat{r}}{r^2}$  everywhere

Q42. [Marks: 2 | MCQ]

Nuclear and Particle Physics · Collective Model



For the given sets of energy levels of nuclei **X** and **Y** whose mass numbers are odd and even, respectively, choose the best suited interpretation.

- (A) Set I: Rotational band of X  
Set II: Vibrational band of Y
- (B) Set I: Rotational band of Y  
Set II: Vibrational band of X
- (C) Set I: Vibrational band of X  
Set II: Rotational band of Y
- (D) Set I: Vibrational band of Y  
Set II: Rotational band of X

Q43. [Marks: 2 | MCQ]

Statistical Mechanics · Microcanonical ensemble

Gate 2021	MCQ	2M
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Consider a system of three distinguishable particles, each having spin  $S = 1/2$  such that  $S_z = \pm 1/2$  with corresponding magnetic moments  $\mu_z = \pm \mu$ . When the system is placed in an external magnetic field  $H$  pointing along the  $z$ -axis, the total energy of the system is  $\mu H$ . Let  $x$  be the state where the first spin has  $S_z = 1/2$ . The probability of having the state  $x$  and the mean magnetic moment (in the  $+z$  direction) of the system in state  $x$  are

(A)  $\frac{1}{3}, \frac{-1}{3} \mu$

(B)  $\frac{1}{3}, \frac{2}{3} \mu$

(C)  $\frac{2}{3}, \frac{-2}{3} \mu$

(D)  $\frac{2}{3}, \frac{1}{3} \mu$

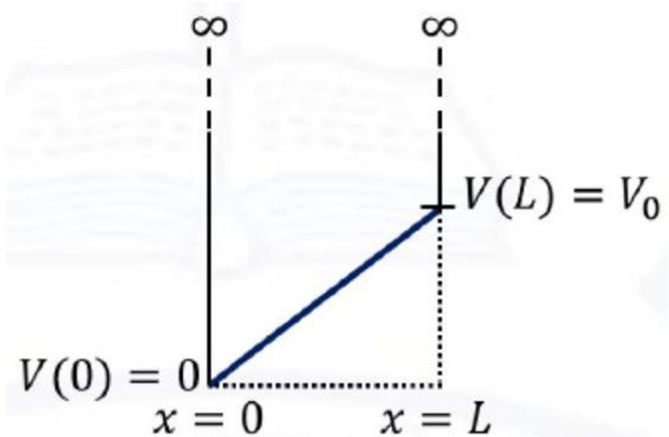
Q44. [Marks: 2 | MCQ]

Quantum Mechanics · Perturbation Theory

Gate 2021	MCQ	2M
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Consider a particle in a one-dimensional infinite potential well with its walls at  $x = 0$  and  $x = L$ . The system is perturbed as shown in the figure. The first order correction to the energy eigenvalue is

- (A)  $\frac{V_0}{4}$
- (B)  $\frac{V_0}{3}$
- (C)  $\frac{V_0}{2}$
- (D)  $\frac{V_0}{5}$



Q45. [Marks: 2 | MCQ]

Quantum Mechanics · Basics Quantum Mechanics

Gate 2021	MCQ	2M
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Consider a state described by  $\psi(x, t) = \psi_2(x, t) + \psi_4(x, t)$ , where  $\psi_2(x, t)$  and  $\psi_4(x, t)$  are respectively the second and fourth normalized harmonic oscillator wave functions and  $\omega$  is the angular frequency of the harmonic oscillator. The wave function  $\psi(x, t = 0)$  will be orthogonal to  $\psi(x, t)$  at time  $t$  equal to

- (A)  $\frac{\pi}{2\omega}$
- (B)  $\frac{\pi}{\omega}$
- (C)  $\frac{\pi}{4\omega}$
- (D)  $\frac{\pi}{6\omega}$

Q46. [Marks: 2 | MCQ]

Statistical Mechanics · Canonical ensemble

Gate 2021	MCQ	2M
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Consider a single one-dimensional harmonic oscillator of angular frequency  $\omega$ , in equilibrium at temperature  $T = (k_B\beta)^{-1}$ . The states of the harmonic oscillator are all non-degenerate having energy  $E_n = \left(n + \frac{1}{2}\right)\hbar\omega$  with equal probability, where  $n$  is the quantum number. The Helmholtz free energy of the oscillator is

- (A)  $\frac{\hbar\omega}{2} + \beta^{-1}\ln[1 - \exp(\beta\hbar\omega)]$   
(B)  $\frac{\hbar\omega}{2} + \beta^{-1}\ln[1 - \exp(-\beta\hbar\omega)]$   
(C)  $\frac{\hbar\omega}{2} + \beta^{-1}\ln[1 + \exp(-\beta\hbar\omega)]$   
(D)  $\beta^{-1}\ln[1 - \exp(-\beta\hbar\omega)]$

Q47. [Marks: 2 | MCQ]

Statistical Mechanics · Canonical ensemble

Gate 2021	MCQ	2M
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A system of two atoms can be in three quantum states having energies  $0, \epsilon$  and  $2\epsilon$ . The system is in equilibrium at temperature  $T = (k_B\beta)^{-1}$ . Match the following Statistics with the Partition function.

Statistics	Partition function
<b>CD:</b> Classical (distinguishable particles)	<b>Z1:</b> $e^{-\beta\epsilon} + e^{-2\beta\epsilon} + e^{-3\beta\epsilon}$
<b>CI:</b> Classical (indistinguishable particles)	<b>Z2:</b> $1 + e^{-\beta\epsilon} + 2e^{-2\beta\epsilon} + e^{-3\beta\epsilon} + e^{-4\beta\epsilon}$
<b>FD:</b> Fermi-Dirac	<b>Z3:</b> $1 + 2e^{-\beta\epsilon} + 3e^{-2\beta\epsilon} + 2e^{-3\beta\epsilon} + e^{-4\beta\epsilon}$
<b>BE:</b> Bose-Einstein	<b>Z4:</b> $\frac{1}{2} + e^{-\beta\epsilon} + \frac{3}{2}e^{-2\beta\epsilon} + e^{-3\beta\epsilon} + \frac{1}{2}e^{-4\beta\epsilon}$

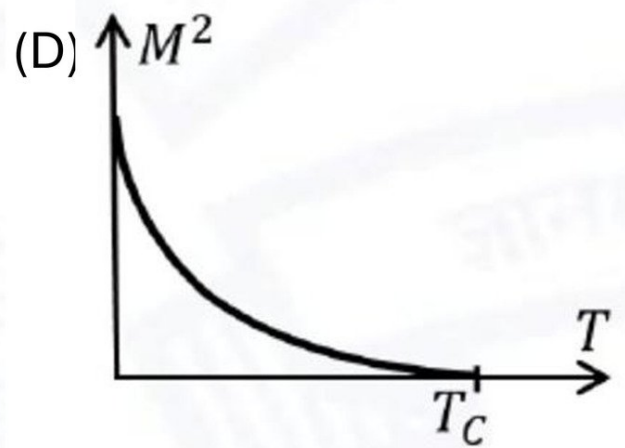
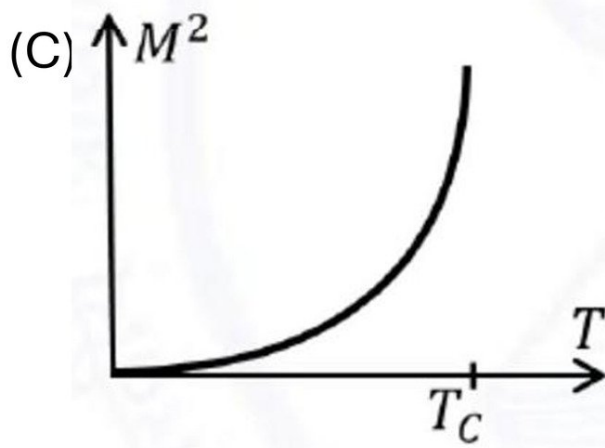
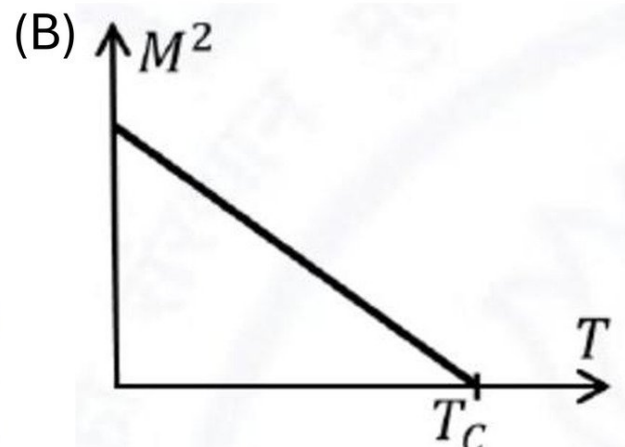
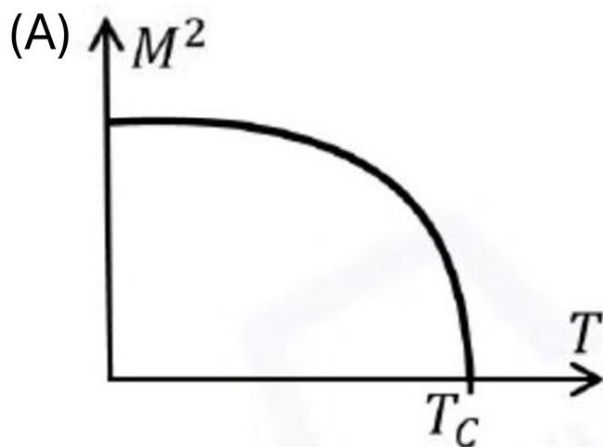
- (A) CD:Z1, CI:Z2, FD:Z3, BE:Z4  
 (B) CD:Z2, CI:Z3, FD:Z4, BE:Z1  
 (C) CD:Z3, CI:Z4, FD:Z1, BE:Z2  
 (D) CD:Z4, CI:Z1, FD:Z2, BE:Z3

Q48. [Marks: 2 | MCQ]

Thermodynamics · Phase transition

Gate 2021	MCQ	2M
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The free energy of a ferromagnet is given by  $F = F_0 + a_0(T - T_C)M^2 + bM^4$ , where  $F_0$ ,  $a_0$ , and  $b$  are positive constants,  $M$  is the magnetization,  $T$  is the temperature, and  $T_C$  is the Curie temperature. The relation between  $M^2$  and  $T$  is best depicted by

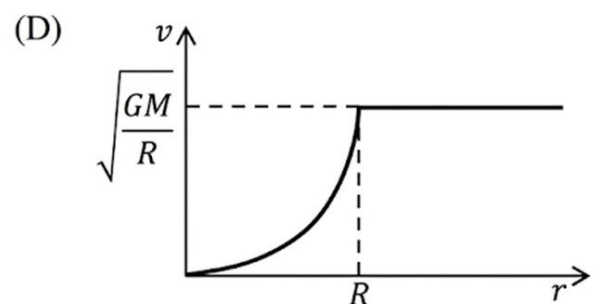
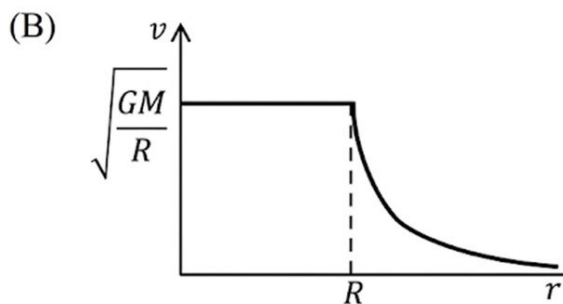
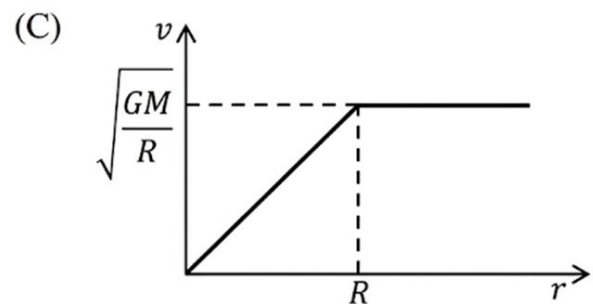
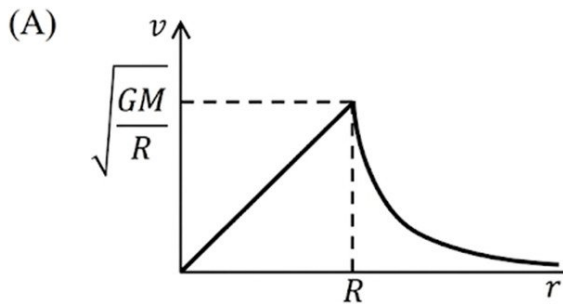


Q49. [Marks: 2 | MCQ]

Classical Mechanics · Central Forces

Gate 2021	MCQ	2M
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Consider a spherical galaxy of total mass  $M$  and radius  $R$ , having a uniform matter distribution. In this idealized situation, the orbital speed  $v$  of a star of mass  $m(m \ll M)$  as a function of the distance  $r$  from the galactic centre is best described by ( $G$  is the universal gravitational constant)



Q50. [Marks: 2 | MCQ]

Quantum Mechanics · Scattering Theory

Gate 2021	MCQ	2M
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Consider the potential  $U(\mathbf{r})$  defined as  $U(r) = -U_0 \frac{e^{-\alpha r}}{r}$  where  $\alpha$  and  $U_0$  are real constants of appropriate dimensions. According to the first Born approximation, the elastic scattering amplitude calculated with  $U(r)$  for a (wave-vector) momentum transfer  $q$  and  $\alpha \rightarrow 0$ , is proportional to

(Useful integral:  $\int_0^\infty \sin(qr) e^{-\alpha r} dr = \frac{q}{\alpha^2 + q^2}$ )

- (A)  $q^{-2}$
- (B)  $q^{-1}$
- (C)  $q$
- (D)  $q^2$

Q51. [Marks: 2 | MCQ]

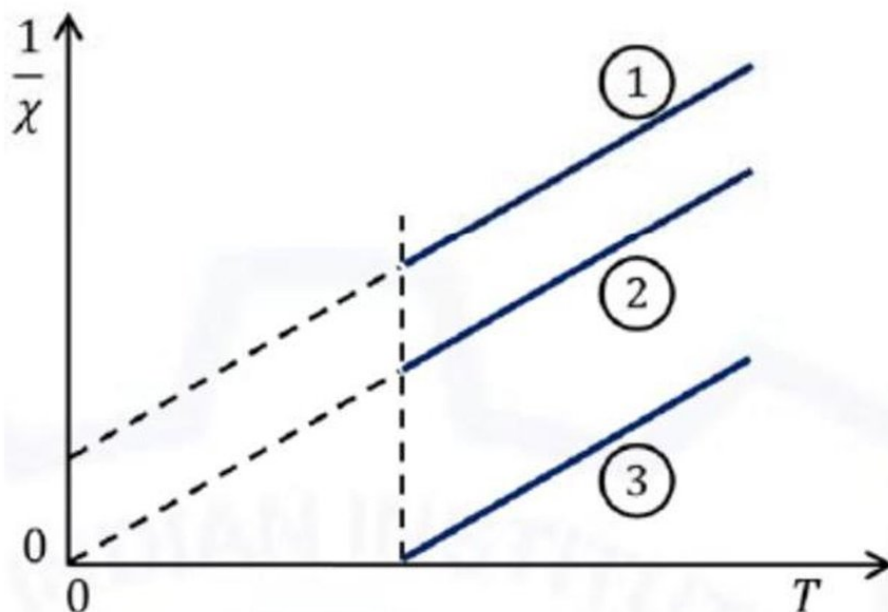
Solid State Physics · Magnetic properties of solids

Gate 2021	MCQ	2M
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As shown in the figure, inverse magnetic susceptibility ( $1/\chi$ ) is plotted as a function of temperature ( $T$ ) for three different materials in paramagnetic states.

(Curie temperature of ferromagnetic material =  $T_C$ )

Néel temperature of antiferromagnetic material =  $T_N$ )



Choose the correct statement from the following

- (A) Material 1 is antiferromagnetic ( $T < T_N$ ), 2 is paramagnetic, and 3 is ferromagnetic ( $T < T_C$ ).
- (B) Material 1 is paramagnetic, 2 is antiferromagnetic ( $T < T_N$ ), and 3 is ferromagnetic ( $T < T_C$ ).
- (C) Material 1 ferromagnetic ( $T < T_C$ ), 2 is antiferromagnetic ( $T < T_N$ ), and 3 is paramagnetic.
- (D) Material 1 is ferromagnetic ( $T < T_C$ ), 2 is paramagnetic, and 3 is antiferromagnetic ( $T < T_N$ ).

Q52. [Marks: 2 | MSQ]

Mathematical Physics · Fourier and Laplace transform

Gate 2021	MSQ	2M
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A function  $f(t)$  is defined only for  $t \geq 0$ . The Laplace transform of  $f(t)$  is  $\mathcal{L}(f; s) = \int_0^{\infty} e^{-st} f(t) dt$

whereas the Fourier transform of  $f(t)$  is  $\tilde{f}(\omega) = \int_0^{\infty} f(t) e^{-i\omega t} dt$

The correct statement(s) is(are)

- (A) The variable  $s$  is always real.
- (B) The variable  $s$  can be complex.
- (C)  $\mathcal{L}(f; s)$  and  $\tilde{f}(\omega)$  can never be made connected.
- (D)  $\mathcal{L}(f; s)$  and  $\tilde{f}(\omega)$  can be made connected.

Q53. [Marks: 2 | MSQ]

Mathematical Physics · Matrices

Gate 2021	MSQ	2M
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$P$  and  $Q$  are two Hermitian matrices and there exists a matrix  $R$ , which diagonalizes both of them, such that  $RPR^{-1} = S_1$  and  $RQR^{-1} = S_2$ , where  $S_1$  and  $S_2$  are diagonal matrices. The correct statement(s) is(are)

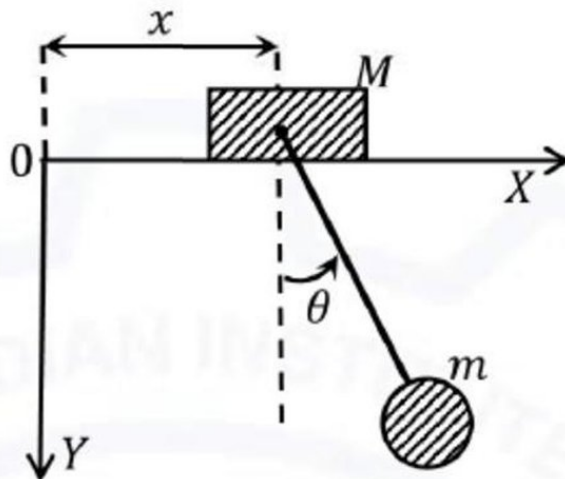
- (A) All the elements of both matrices  $S_1$  and  $S_2$  are real.
- (B) The matrix  $PQ$  can have complex eigenvalues.
- (C) The matrix  $QP$  can have complex eigenvalues.
- (D) The matrices  $P$  and  $Q$  commute.

Q54. [Marks: 2 | MSQ]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2021	MSQ	2M
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A uniform block of mass  $M$  slides on a smooth horizontal bar. Another mass  $m$  is connected to it by an inextensible string of length  $l$  of negligible mass, and is constrained to oscillate in the X-Y plane only. Neglect the sizes of the masses. The number of degrees of freedom of the system is two and the generalized coordinates are chosen as  $x$  and  $\theta$ , as shown in the figure.



If  $p_x$  and  $p_\theta$  are the generalized momenta corresponding to  $x$  and  $\theta$ , respectively, then the correct option(s) is(are)

- (A)  $p_x = (m + M)\dot{x} + ml\cos\theta\dot{\theta}$
- (B)  $p_\theta = ml^2\dot{\theta} - ml\cos\theta\dot{x}$
- (C)  $p_x$  is conserved
- (D)  $p_\theta$  is conserved

Q55. [Marks: 2 | MSQ]

Nuclear and Particle Physics · Particle Physics

Gate 2021	MSQ	2M
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The Gell-Mann-Okuba mass formula defines the mass of baryons as

$M = M_0 + aY + b \left[ I(I + 1) - \frac{1}{4}Y^2 \right]$ , where  $M_0$ ,  $a$  and  $b$  are constants,  $I$  represents the isospin and  $Y$  represents the hypercharge. If the mass of  $\Sigma$  hyperons is same as that of  $\Lambda$  hyperons, then the correct option(s) is(are)

- (A)  $M \propto I(I + 1)$
- (B)  $M \propto Y$
- (C)  $M$  does not depend on  $I$
- (D)  $M$  does not depend on  $Y$

Q56. [Marks: 2 | MSQ]

Classical Mechanics · Lagrangian and Hamiltonian

Gate 2021	MSQ	2M
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The time derivative of a differentiable function  $g(\mathbf{q}_i, t)$  is added to a Lagrangian  $L(\mathbf{q}_i, \dot{\mathbf{q}}_i, t)$  such that  $L' = L(\mathbf{q}_i, \dot{\mathbf{q}}_i, t) + \frac{d}{dt}g(\mathbf{q}_i, t)$  where  $\mathbf{q}_i, \dot{\mathbf{q}}_i, t$  are the generalized coordinates, generalized velocities and time, respectively. Let  $\mathbf{p}_i$  be the generalized momentum and  $H$  the Hamiltonian associated with  $L(\mathbf{q}_i, \dot{\mathbf{q}}_i, t)$ . If  $\mathbf{p}'_i$  and  $H'$  are those associated with  $L'$ , then the correct option(s) is(are)

- (A) Both  $L$  and  $L'$  satisfy the Euler-Lagrange's equations of motion
- (B)  $\mathbf{p}'_i = \mathbf{p}_i + \frac{\partial}{\partial \dot{\mathbf{q}}_i} g(\mathbf{q}_i, t)$
- (C) If  $\mathbf{p}_i$  is conserved, then  $\mathbf{p}'_i$  is necessarily conserved
- (D)  $H' = H + \frac{d}{dt}g(\mathbf{q}_i, t)$

Q57. [Marks: 2 | NAT]

Nuclear and Particle Physics · Particle detector and accelerator

Gate 2021	NAT	2M
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A linear charged particle accelerator is driven by an alternating voltage source operating at 10 MHz. Assume that it is used to accelerate electrons. After a few drift-tubes, the electrons attain a velocity  $2.9 \times 10^8 \text{ m s}^{-1}$ . The minimum length of each drift-tube, in m, to accelerate the electrons further (rounded off to one decimal place) is\_\_\_\_\_.

Q58. [Marks: 2 | NAT]

Nuclear and Particle Physics · Liquid Drop Model

Gate 2021	NAT	2M
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The Coulomb energy component in the binding energy of a nucleus is 18.432 MeV. If the radius of the uniform and spherical charge distribution in the nucleus is 3 fm, the corresponding atomic number (rounded off to the nearest integer) is\_\_\_\_\_.

(Given :  $\frac{e^2}{4\pi\epsilon_0} = 1.44\text{MeVfm}$ )

**Q59. [Marks: 2 | NAT]**

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

Gate 2021	NAT	2M
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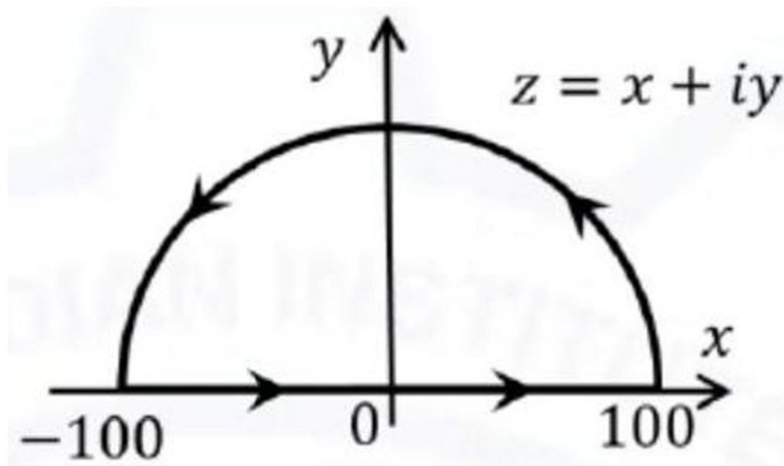
For a two-nucleon system in spin singlet state, the spin is represented through the Pauli matrices  $\sigma_1, \sigma_2$  for particles 1 and 2, respectively. The value of  $(\sigma_1 \cdot \sigma_2)$  (in integer) is\_\_\_\_\_.

Q60. [Marks: 2 | NAT]

Mathematical Physics · Complex Analysis

Gate 2021	NAT	2M
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A contour integral is defined as  $I_n = \oint_C \frac{dz}{(z-n)^2 + \pi^2}$  where  $n$  is a positive integer and  $C$  is the closed contour, as shown in the figure, consisting of the line from  $-100$  to  $100$  and the semicircle traversed in the counter-clockwise sense. The value of  $\sum_{n=1}^5 I_n$  (in integer) is \_\_\_\_ .



Q61. [Marks: 2 | NAT]

Quantum Mechanics · Orbital angular momentum and hydrogen atom

Gate 2021	NAT	2M
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The normalized radial wave function of the second excited state of hydrogen atom is

$R(r) = \frac{1}{\sqrt{24}} a^{-3/2} \frac{r}{a} e^{-r/2a}$  where  $a$  is the Bohr radius and  $r$  is the distance from the center of the atom. The distance at which the electron is most likely to be found is  $y \times a$ . The value of  $y$  (in integer) is \_\_\_\_ .

Q62. [Marks: 2 | NAT]

Solid State Physics · Magnetic properties of solids

Gate 2021	NAT	2M
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Consider an atomic gas with number density  $n = 10^{20} \text{ m}^{-3}$ , in the ground state at 300 K . The valence electronic configuration of atoms is  $f^7$ . The paramagnetic susceptibility of the gas  $\chi = m \times 10^{-11}$ . The value of  $m$  (rounded off to two decimal places) is \_\_\_\_ .

(Given: Magnetic permeability of free space  $\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$

Bohr magneton  $\mu_B = 9.274 \times 10^{-24} \text{ A m}^2$

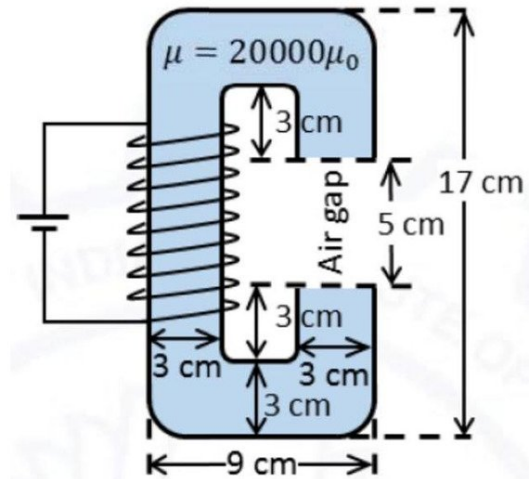
Boltzmann constant  $k_B = 1.3807 \times 10^{-23} \text{ J K}^{-1}$  )

Q63. [Marks: 2 | NAT]

Electromagnetism · Magnetism

Gate 2021	NAT	2M
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Consider a cross-section of an electromagnet having an air-gap of 5 cm as shown in the figure. It consists of a magnetic material ( $\mu = 20000\mu_0$ ) and is driven by a coil having  $NI = 10^4$  A,



where  $N$  is the number of turns and  $I$  is the current in Ampere. Ignoring the fringe fields, the magnitude of the magnetic field  $\vec{B}$  (in Tesla, rounded off to two decimal places) in the air-gap between the magnetic poles is \_\_\_\_ .

Q64. [Marks: 2 | NAT]

Atomic and Molecular Physics · Vector Model

Gate 2021	NAT	2M
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The spin  $\vec{S}$  and orbital angular momentum  $\vec{L}$  of an atom precess about  $\vec{J}$ , the total angular momentum.  $\vec{J}$  precesses about an axis fixed by a magnetic field  $\vec{B}_1 = 2B_0\hat{z}$ , where  $B_0$  is a constant. Now the magnetic field is changed to  $\vec{B}_2 = B_0(\hat{x} + \sqrt{2}\hat{y} + \hat{z})$ . Given the orbital angular momentum quantum number  $l = 2$  and spin quantum number  $s = 1/2$ ,  $\theta$  is the angle between  $\vec{B}_1$  and  $\vec{J}$  for the largest possible values of total angular quantum number  $j$  and its  $z$ -component  $j_z$ . The value of  $\theta$  (in degree, rounded off to the nearest integer) is \_\_\_\_ .

Q65. [Marks: 2 | NAT]

Atomic and Molecular Physics · Effects in atomic physics

Gate 2021	NAT	2M
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The spin-orbit effect splits the  ${}^2P \rightarrow {}^2S$  transition (wavelength,  $\lambda = 6521\text{\AA}$ ) in Lithium into two lines with separation of  $\Delta\lambda = 0.14\text{\AA}$ . The corresponding positive value of energy difference between the above two lines, in eV, is  $m \times 10^{-5}$ . The value of  $m$  (rounded off to the nearest integer) is \_\_\_\_ .

(Given: Planck's constant,  $h = 4.125 \times 10^{-15} \text{eVs}$   
Speed of light,  $c = 3 \times 10^8 \text{ m s}^{-1}$  )

# 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	<b>B</b>
Q2	General Aptitude	Reasoning	MCQ	1	<b>B</b>
Q3	General Aptitude	Mathematical Analysis	MCQ	1	<b>D</b>
Q4	General Aptitude	Reasoning	MCQ	1	<b>D</b>
Q5	General Aptitude	Mathematical Analysis	MCQ	1	<b>C</b>
Q6	General Aptitude	Geometry	MCQ	2	<b>C</b>
Q7	General Aptitude	Reasoning	MCQ	2	<b>A</b>
Q8	General Aptitude	Reasoning	MCQ	2	<b>B</b>
Q9	General Aptitude	Geometry	MCQ	2	<b>C</b>
Q10	General Aptitude	Geometry	MCQ	2	<b>D</b>
Q11	Solid State Physics	Dielectric Properties of solid	MCQ	1	<b>A</b>
Q12	Electromagnetism	EM Waves	MCQ	1	<b>A</b>
Q13	Solid State Physics	Xray diffraction	MCQ	1	<b>B</b>
Q14	Solid State Physics	Semiconductor Physics	MCQ	1	<b>A</b>
Q15	Electromagnetism	Electrodynamics	MCQ	1	<b>C</b>
Q16	Electromagnetism	Magnetism	MCQ	1	<b>C</b>
Q17	Nuclear and Particle Phy...	Radioactivity	MCQ	1	<b>A</b>
Q18	Nuclear and Particle Phy...	Radioactivity	MCQ	1	<b>D</b>
Q19	Solid State Physics	Semiconductor Physics	MCQ	1	<b>B</b>
Q20	Solid State Physics	Tight binding model	MSQ	1	<b>B; C; D</b>
Q21	Optics	Polarization	MSQ	1	<b>B</b>
Q22	Electromagnetism	Magnetism in matter	MSQ	1	<b>B; D</b>
Q23	Statistical Mechanics	Quantum Statistical Mechanics	MSQ	1	<b>A; D</b>
Q24	Atomic and Molecular Ph...	Effects in atomic physics	MSQ	1	<b>C; D</b>
Q25	Atomic and Molecular Ph...	Lasers	MSQ	1	<b>A; B</b>
Q26	Mathematical Physics	Special functions	MSQ	1	<b>B; C</b>
Q27	Solid State Physics	Semiconductor Physics	NAT	1	<b>115 to 116</b>
Q28	Classical Mechanics	Special theory of relativity	NAT	1	<b>2 to 2</b>
Q29	Statistical Mechanics	Quantum Statistical Mechanics	NAT	1	<b>5000 to 5000</b>
Q30	Classical Mechanics	Lagrangian and Hamiltonian	NAT	1	<b>2 to 2</b>
Q31	Statistical Mechanics	Microstates	NAT	1	<b>5 to 6</b>
Q32	Atomic and Molecular Ph...	Molecular Physics	NAT	1	<b>17367 to 17371</b>
Q33	Atomic and Molecular Ph...	Lasers	NAT	1	<b>6 to 6</b>
Q34	Atomic and Molecular Ph...	Effects in atomic physics	NAT	1	<b>2 to 2</b>
Q35	Classical Mechanics	Canonical Transformation and Poiss...	NAT	1	<b>-1 to -1</b>
Q36	Electronics	Logic Gates	MCQ	2	<b>B</b>

# Answer Key

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

Q.No	Subject	Topic	Type	Marks	Answer
Q37	Solid State Physics	Semiconductor Physics	MCQ	2	<b>D</b>
Q38	Quantum Mechanics	Spin and Total Angular momentum	MCQ	2	<b>D</b>
Q39	Electromagnetism	EM Waves	MCQ	2	<b>A</b>
Q40	Classical Mechanics	Lagrangian and Hamiltonian	MCQ	2	<b>D</b>
Q41	Electromagnetism	Electric field in matter	MCQ	2	<b>A</b>
Q42	Nuclear and Particle Phy...	Collective Model	MCQ	2	<b>D</b>
Q43	Statistical Mechanics	Microcanonical ensemble	MCQ	2	<b>A</b>
Q44	Quantum Mechanics	Perturbation Theory	MCQ	2	<b>C</b>
Q45	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	<b>A</b>
Q46	Statistical Mechanics	Canonical ensemble	MCQ	2	<b>B</b>
Q47	Statistical Mechanics	Canonical ensemble	MCQ	2	<b>C</b>
Q48	Thermodynamics	Phase transition	MCQ	2	<b>B</b>
Q49	Classical Mechanics	Central Forces	MCQ	2	<b>A</b>
Q50	Quantum Mechanics	Scattering Theory	MCQ	2	<b>A</b>
Q51	Solid State Physics	Magnetic properties of solids	MCQ	2	<b>A</b>
Q52	Mathematical Physics	Fourier and Laplace transform	MSQ	2	<b>B; D</b>
Q53	Mathematical Physics	Matrices	MSQ	2	<b>A; D</b>
Q54	Classical Mechanics	Lagrangian and Hamiltonian	MSQ	2	<b>A; C</b>
Q55	Nuclear and Particle Phy...	Particle Physics	MSQ	2	<b>B; C</b>
Q56	Classical Mechanics	Lagrangian and Hamiltonian	MSQ	2	<b>A; B</b>
Q57	Nuclear and Particle Phy...	Particle detector and accelerator	NAT	2	<b>14.0 to 15.0</b>
Q58	Nuclear and Particle Phy...	Liquid Drop Model	NAT	2	<b>8 to 8 OR 9 to 9</b>
Q59	Nuclear and Particle Phy...	Nuclear Force, deuteron problem an...	NAT	2	<b>-3 to -3</b>
Q60	Mathematical Physics	Complex Analysis	NAT	2	<b>5 to 5</b>
Q61	Quantum Mechanics	Orbital angular momentum and hydr...	NAT	2	<b>4 to 4</b>
Q62	Solid State Physics	Magnetic properties of solids	NAT	2	<b>5.40 to 5.50</b>
Q63	Electromagnetism	Magnetism	NAT	2	<b>0.24 to 0.26</b>
Q64	Atomic and Molecular Ph...	Vector Model	NAT	2	<b>27 to 93</b>
Q65	Atomic and Molecular Ph...	Effects in atomic physics	NAT	2	<b>3 to 5</b>