# PhysicsByAaryan

CSIR NET · GATE · JEST · BARC – Physics

## GATE Physics 2013 — Full Question Paper

Previous Year Questions with Official Answer Key

### Inside this PDF

- Every GATE Physics (PH) 2013 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]** Mathematical Physics · Fourier and Laplace transform

| Gate 2013 | MCQ | 1M |
|---|---|---|

$f(x)$ is a symmetric periodic function of $x$ i.e. $f(x) = f(-x)$. Then, in general, the Fourier series of the function $f(x)$ will be of the form

(A) $f(x) = \sum_{n=1}^{\infty} (a_n \cos(nkx) + b_n \sin(nkx))$

(B) $f(x) = a_0 + \sum_{n=1}^{\infty} (a_n \cos(nkx))$

(C) $f(x) = \sum_{n=1}^{\infty} (b_n \sin(nkx))$

(D) $f(x) = a_0 + \sum_{n=1}^{\infty} (b_n \sin(nkx))$

**Q2. [Marks: 1 | MCQ]** Mathematical Physics · Tensors

| Gate 2013 | MCQ | 1M |
|---|---|---|

In the most general case, which one of the following quantities is NOT a second order tensor?

(A) Stress

(B) Strain

(C) Moment of inertia

(D) Pressure

**Q3. [Marks: 1 | MCQ]** Classical Mechanics · Special theory of relativity

| Gate 2013 | MCQ | 1M |
|---|---|---|

An electron is moving with a velocity of $0.85c$ in the same direction as that of a moving photon. The relative velocity of the electron with respect to photon is

(A) $c$

(B) $-c$

(C) $0.15c$

(D) $-0.15c$

**Q4. [Marks: 1 | MCQ]** Statistical Mechanics · Quantum Statistical Mechanics

| Gate 2013 | MCQ | 1M |
|---|---|---|

If Planck's constant were zero, then the total energy contained in a box filled with radiation of all frequencies at temperature $T$ would be ( $k$ is the Boltzmann constant and $T$ is nonzero)

(A) Zero

(B) Infinite

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

(D) $kT$

**Q5. [Marks: 1 | MCQ]** Thermodynamics · Phase transition

| Gate 2013 | MCQ | 1M |
|---|---|---|

Across a first order phase transition, the free energy is

(A) proportional to the temperature

(B) a discontinuous function of the temperature

(C) a continuous function of the temperature but its first derivative is discontinuous

(D) such that the first derivative with respect to temperature is continuous

**Q6. [Marks: 1 | MCQ]** Thermodynamics · Laws of thermodynamics

| Gate 2013 | MCQ | 1M |
|---|---|---|

Two gases separated by an impermeable but movable partition are allowed to freely exchange energy. At equilibrium, the two sides will have the same

(A) pressure and temperature

(B) volume and temperature

(C) pressure and volume

(D) volume and energy

**Q7. [Marks: 1 | MCQ]** Statistical Mechanics · Microcanonical ensemble

| Gate 2013 | MCQ | 1M |
|---|---|---|

The entropy function of a system is given by

$$S(E) = aE(E_0 - E)$$

where $a$ and $E_0$ are positive constants. The temperature of the system is

(A) negative for some energies

(B) increases monotonically with energy

(C) decreases monotonically with energy

(D) Zero

**Q8. [Marks: 1 | MCQ]** Statistical Mechanics · Microstates

| Gate 2013 | MCQ | 1M |
|---|---|---|

Consider a linear collection of $N$ independent spin $1/2$ particles, each at a fixed location. The entropy of this system is ( $k$ is the Boltzmann constant)

(A) Zero

(B) $Nk$

(C) $\frac{1}{2}\mathrm{Nk}$

(D) $Nk\ln(2)$

**Q9. [Marks: 1 | MCQ]** Nuclear and Particle Physics · Particle Physics

| Gate 2013 | MCQ | 1M |
|---|---|---|

The decay process $n \rightarrow p^{+} + e^{-} + \bar{\nu}_e$ violates

(A) baryon number

(B) lepton number

(C) Isospin

(D) strangeness

**Q10. [Marks: 1 | MCQ]** Nuclear and Particle Physics · Particle Physics

| Gate 2013 | MCQ | 1M |
|---|---|---|

The isospin (I) and baryon number (B) of the up quark is

(A) $I = 1,\ B = 1$

(B) $I = 1, B = 1/3$

(C) $I = 1/2, B = 1$

(D) $I = 1/2,\ B = 1/3$

**Q11. [Marks: 1 | MCQ]** Nuclear and Particle Physics · Nuclear Force, deuteron problem and scatteri

| Gate 2013 | MCQ | 1M |
|---|---|---|

Consider the scattering of neutrons by protons at very low energy due to a nuclear potential of range $r_0$. Given that,

$$\cot(kr_0 + \delta) \approx -\frac{\gamma}{k}$$

where $\delta$ is the phase shift, $k$ the wave number and $(-\gamma)$ the logarithmic derivative of the deuteron ground state wave function, the phase shift is

(A) $\delta \approx -\frac{k}{\gamma} - kr_0$

(B) $\delta \approx -\frac{\gamma}{k} - kr_0$

(C) $\delta \approx \frac{\pi}{2} - kr_0$

(D) $\delta \approx -\frac{\pi}{2} - kr_0$

**Q12. [Marks: 1 | MCQ]** Nuclear and Particle Physics · Radioactivity

| Gate 2013 | MCQ | 1M |
|---|---|---|

In the $\beta$ decay process, the transition $2^+ \rightarrow 3^+$, is

(A) allowed both by Fermi and Gamow-Teller selection rule

(B) allowed by Fermi and but not by Gamow-Teller selection rule

(C) not allowed by Fermi but allowed by Gamow-Teller selection rule

(D) not allowed both by Fermi and Gamow-Teller selection rule

**Q13. [Marks: 1 | MCQ]** Electromagnetism · Magnetism

| Gate 2013 | MCQ | 1M |
|---|---|---|

At a surface current, which one of the magnetostatic boundary condition is NOT CORRECT?

(A) Normal component of the magnetic field is continuous.

(B) Normal component of the magnetic vector potential is continuous.

(C) Tangential component of the magnetic vector potential is continuous.

(D) Tangential component of the magnetic vector potential is not continuous.

**Q14. [Marks: 1 | MCQ]** Optics · Interference and Diffraction

| Gate 2013 | MCQ | 1M |
|---|---|---|

Interference fringes are seen at an observation plane $z = 0$, by the superposition of two plane waves

$A_1 \exp\left[i\left(\vec{k}_1 \cdot \vec{r} - \omega t\right)\right]$ and $A_2 \exp\left[i\left(\vec{k}_2 \cdot \vec{r} - \omega t\right)\right]$,

where $A_1$ and $A_2$ are real amplitudes. The condition for interference maximum is

(A) $\left(\vec{k}_1 - \vec{k}_2\right) \cdot \vec{r} = (2m + 1)\pi$

(B) $\left(\vec{k}_1 - \vec{k}_2\right) \cdot \vec{r} = 2m\pi$

(C) $\left(\vec{k}_1 + \vec{k}_2\right) \cdot \vec{r} = (2m + 1)\pi$

(D) $\left(\vec{k}_1 + \vec{k}_2\right) \cdot \vec{r} = 2m\pi$

**Q15. [Marks: 1 | MCQ]** Mathematical Physics · Vector Analysis

| Gate 2013 | MCQ | 1M |
|---|---|---|

For a scalar function $\varphi$ satisfying the Laplace equation, $\nabla\varphi$ has

(A) zero curl and non-zero divergence

(B) non-zero curl and zero divergence

(C) zero curl and zero divergence

(D) non-zero curl and non-zero divergence

**Q16. [Marks: 1 | MCQ]** Optics · Polarization

| Gate 2013 | MCQ | 1M |
|---|---|---|

A circularly polarized monochromatic plane wave is incident on a dielectric interface at Brewster angle. Which one of the following statements is CORRECT ?

(A) The reflected light is plane polarized in the plane of incidence and the transmitted light is circularly polarized.

(B) The reflected light is plane polarized perpendicular to the plane of incidence and the transmitted light is plane polarized in the plane of incidence.

(C) The reflected light is plane polarized perpendicular to the plane of incidence and the transmitted light is elliptically polarized.

(D) There will be no reflected light and the transmitted light is circularly polarized.

**Q17. [Marks: 1 | MCQ]** Quantum Mechanics · Orbital angular momentum and hydrogen atom

| Gate 2013 | MCQ | 1M |
|---|---|---|

Which one of the following commutation relations is NOT CORRECT ? Here, symbols have their usual meanings.

(A) $[L^2, L_z] = 0$

(B) $[L_x, L_y] = i\hbar L_z$

(C) $[L_Z, L_+] = \hbar L_+$

(D) $[L_Z, L_-] = \hbar L_-$

**Q18. [Marks: 1 | MCQ]** Classical Mechanics · Lagrangian and Hamiltonian

| Gate 2013 | MCQ | 1M |
|---|---|---|

The Lagrangian of a system with one degree of freedom $q$ is given by $L = \alpha\dot{q}^2 + \beta q^2$, where $\alpha$ and $\beta$ are non-zero constants. If $p_q$ denotes the canonical momentum conjugate to $q$ then which one of the following statements is CORRECT?

(A) $p_q = 2\beta q$ and it is a conserved quantity.

(B) $p_q = 2\beta q$ and it is not a conserved quantity.

(C) $p_q = 2\alpha\dot{q}$ and it is a conserved quantity.

(D) $p_q = 2\alpha\dot{q}$ and it is not a conserved quantity.

**Q19. [Marks: 1 | MCQ]** Electronics · AD/DA coversion

| Gate 2013 | MCQ | 1M |
|---|---|---|

What should be the clock frequency of a 6-bit A/D converter so that its maximum conversion time is $32\mu s$ ?

(A) 1 MHz

(B) 2 MHz

(C) 0.5 MHz

(D) 4 MHz

**Q20. [Marks: 1 | MCQ]** Solid State Physics · Semiconductor Physics

| Gate 2013 | MCQ | 1M |
|---|---|---|

A phosphorous doped silicon semiconductor (doping density: $10^{17}/\text{cm}^3$ ) is heated from $100°\text{C}$ to $200°\text{C}$. Which one of the following statements is CORRECT?

(A) Position of Fermi level moves towards conduction band

(B) Position of dopant level moves towards conduction band

(C) Position of Fermi level moves towards middle of energy gap

(D) Position of dopant level moves towards middle of energy gap

**Q21. [Marks: 1 | MCQ]** Solid State Physics · Superconductivity

| Gate 2013 | MCQ | 1M |
|---|---|---|

Considering the BCS theory of superconductors, which one of the following statements is NOT CORRECT?
( $h$ is the Planck's constant and $e$ is the electronic charge)

(A) Presence of energy gap at temperatures below the critical temperature

(B) Different critical temperatures for isotopes

(C) Quantization of magnetic flux in superconducting ring in the unit of $\left(\frac{h}{e}\right)$

(D) Presence of Meissner effect

**Q22. [Marks: 1 | MCQ]** Solid State Physics · Lattice vibration

| Gate 2013 | MCQ | 1M |
|---|---|---|

Group I contains elementary excitations in solids. Group II gives the associated fields with these excitations. MATCH the excitations with their associated field and select your answer as per codes given below.

| Group I | Group II |
|---|---|
| (P) phonon | (i) photon + lattice vibration |
| (Q) plasmon | (ii) electron + elastic deformation |
| (R) polaron | (iii) collective electron oscillations |
| (S) polariton | (iv) elastic wave |

Codes

(A) (P-iv), (Q-iii), (R-i), (S-ii)

(B) (P-iv), (Q-iii), (R-ii), (S-i)

(C) (P-i), (Q-iii), (R-ii), (S-iv)

(D) (P-iii), (Q-iv), (R-ii), (S-i)

**Q23. [Marks: 1 | NAT]** Statistical Mechanics · Microstates

| Gate 2013 | NAT | 1M |
|---|---|---|

The number of distinct ways of placing four indistinguishable balls into five distinguishable boxes is ___ .

**Q24. [Marks: 1 | NAT]** Electronics · Diodes

| Gate 2013 | NAT | 1M |
|---|---|---|

A voltage regulator has ripple rejection of -50 dB . If input ripple is 1 mV , what is the output ripple voltage in $\mu$V ? The answer should be up to two decimal places. ___

**Q25. [Marks: 1 | NAT]** Atomic and Molecular Physics · Effects in atomic physics

| Gate 2013 | NAT | 1M |
|---|---|---|

The number of spectral lines allowed in the spectrum for the $3\,^2D \rightarrow 3\,^2P$ transition in sodium is___ .

**Q26. [Marks: 2 | MCQ]** Mathematical Physics · Fourier and Laplace transform

| Gate 2013 | MCQ | 2M |
|---|---|---|

Which of the following pairs of the given function $F(t)$ and its Laplace transform $f(s)$ is NOT CORRECT?

(A) $F(t) = \delta(t), f(s) = 1,$ (Singularity at +0 )

(B) $F(t) = 1, f(s) = \frac{1}{s}, (s > 0)$

(C) $F(t) = \sin kt, f(s) = \frac{s}{s^2+k^2}, (s > 0)$

(D) $F(t) = te^{kt}, f(s) = \frac{1}{(s-k)^2}, (s > k, s > 0)$

**Q27. [Marks: 2 | MCQ]** Mathematical Physics · Vector Analysis

| Gate 2013 | MCQ | 2M |
|---|---|---|

If $\vec{A}$ and $\vec{B}$ are constant vectors, then $\nabla(\vec{A} \cdot \vec{B} \times \vec{r})$ is

(A) $\vec{A} \cdot \vec{B}$

(B) $\vec{A} \times \vec{B}$

(C) $\vec{r}$

(D) Zero

**Q28. [Marks: 2 | MCQ]** Mathematical Physics · Gamma, Beta and Delta function

| Gate 2013 | MCQ | 2M |
|---|---|---|

$\Gamma\left(n+\frac{1}{2}\right)$ is equal to [Given $\Gamma(n+1)=n\Gamma(n)$ and $\Gamma(1/2)=\sqrt{\pi}$ ]

(A) $\frac{n!}{2^n}\sqrt{\pi}$

(B) $\frac{2n!}{n!2^n}\sqrt{\pi}$

(C) $\frac{2n!}{n!2^{2n}}\sqrt{\pi}$

(D) $\frac{n!}{2^{2n}}\sqrt{\pi}$

**Q29. [Marks: 2 | MCQ]** Electromagnetism · Relativistic EMT

| Gate 2013 | MCQ | 2M |
|---|---|---|

The relativistic form of Newton's second law of motion is

(A) $F = \frac{mc}{\sqrt{c^2-v^2}}\frac{dv}{dt}$

(B) $F = \frac{m\sqrt{c^2-v^2}}{c}\frac{dv}{dt}$

(C) $F = \frac{mc^2}{c^2-v^2}\frac{dv}{dt}$

(D) $F = m\frac{c^2-v^2}{c^2}\frac{dv}{dt}$

**Q30. [Marks: 2 | MCQ]** Statistical Mechanics · Canonical ensemble

| Gate 2013 | MCQ | 2M |
|---|---|---|

Consider a gas of atoms obeying Maxwell-Boltzmann statistics. The average value of $e^{i\vec{a}\cdot\vec{p}}$ over all the momenta $\vec{p}$ of each of the particles (where $\vec{a}$ is a constant vector and $a$ is its magnitude, $m$ is the mass of each atom, $T$ is temperature and $k$ is Boltzmann's constant) is,

(A) One

(B) Zero

(C) $e^{-\frac{1}{2}a^2mkT}$

(D) $e^{-\frac{3}{2}a^2mkT}$

**Q31. [Marks: 2 | MCQ]** Nuclear and Particle Physics · Nuclear properties

| Gate 2013 | MCQ | 2M |
|---|---|---|

The electromagnetic form factor $F(q^2)$ of a nucleus is given by,

$$F(q^2) = \exp\left[-\frac{q^2}{2Q^2}\right]$$

where $Q$ is a constant. Given that

$$F(q^2) = \frac{4\pi}{q}\int_0^\infty r dr \rho(r) \sin qr$$

$$\int d^3 r \rho(r) = 1$$

where $\rho(\mathrm{r})$ is the charge density, the root mean square radius of the nucleus is given by,

(A) $1/Q$

(B) $\sqrt{2}/Q$

(C) $\sqrt{3}/Q$

(D) $\sqrt{6}/Q$

**Q32. [Marks: 2 | MCQ]** Classical Mechanics · Rotation Motion

| Gate 2013 | MCQ | 2M |
|---|---|---|

A uniform circular disk of radius $R$ and mass $M$ is rotating with angular speed $\omega$ about an axis, passing through its center and inclined at an angle 60 degrees with respect to its symmetry axis. The magnitude of the angular momentum of the disk is,

(A) $\frac{\sqrt{3}}{4}\omega MR^2$

(B) $\frac{\sqrt{3}}{8}\omega MR^2$

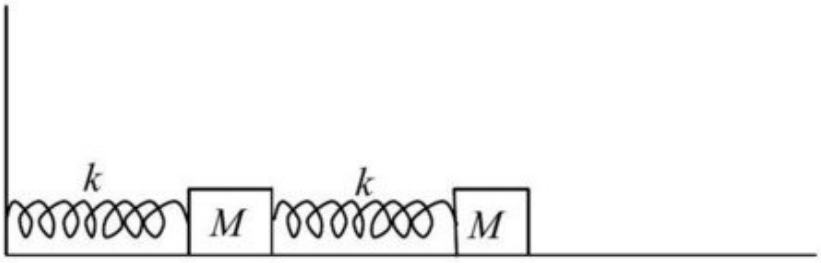
(C) $\frac{\sqrt{7}}{8}\omega MR^2$

(D) $\frac{\sqrt{7}}{4}\omega MR^2$

**Q33. [Marks: 2 | MCQ]** Classical Mechanics · Small Oscillations

| Gate 2013 | MCQ | 2M |
|---|---|---|

Consider two small blocks, each of mass $M$, attached to two identical springs. One of the springs is attached to the wall, as shown in the figure. The spring constant of each spring is $k$. The masses slide along the surface and the friction is negligible. The frequency of one of the normal modes of the system is,




(A) $\sqrt{\frac{3+\sqrt{2}}{2}}\sqrt{\frac{k}{M}}$

(B) $\sqrt{\frac{3+\sqrt{3}}{2}}\sqrt{\frac{k}{M}}$

(C) $\sqrt{\frac{3+\sqrt{5}}{2}}\sqrt{\frac{k}{M}}$

(D) $\sqrt{\frac{3+\sqrt{6}}{2}}\sqrt{\frac{k}{M}}$

**Q34. [Marks: 2 | MCQ]** Electromagnetism · Electrostatics

| Gate 2013 | MCQ | 2M |
|---|---|---|

A charge distribution has the charge density given by $\rho = Q\{\delta(x - x_0) - \delta(x + x_0)\}$. For this charge distribution the electric field at $(2x_0, 0, 0)$

(A) $\frac{2Q\hat{x}}{9\pi\epsilon_0 x_0^2}$

(B) $\frac{Q\hat{x}}{4\pi\epsilon_0 x_0^3}$

(C) $\frac{Q\hat{x}}{4\pi\epsilon_0 x_0^2}$

(D) $\frac{Q\hat{x}}{16\pi\epsilon_0 x_0^2}$

**Q35. [Marks: 2 | MCQ]** Electromagnetism · EM Waves

| Gate 2013 | MCQ | 2M |
|---|---|---|

A monochromatic plane wave at oblique incidence undergoes reflection at a dielectric interface. If $\hat{k}_i, \hat{k}_r$ and $\hat{n}$ are the unit vectors in the directions of incident wave, reflected wave and the normal to the surface respectively, which one of the following expressions is correct?

(A) $\left(\hat{k}_i - \hat{k}_r\right) \times \hat{n} \neq 0$

(B) $\left(\hat{k}_i - \hat{k}_r\right) \cdot \hat{n} = 0$

(C) $\left(\hat{k}_i \times \hat{n}\right) \cdot \hat{k}_r = 0$

(D) $\left(\hat{k}_i \times \hat{n}\right) \cdot \hat{k}_r \neq 0$

**Q36. [Marks: 2 | MCQ]** Atomic and Molecular Physics · Effects in atomic physics

| Gate 2013 | MCQ | 2M |
|---|---|---|

In a normal Zeeman effect experiment, spectral splitting of the line at the wavelength 643.8 nm corresponding to the transition $5\,^1D_2 \rightarrow 5\,^1P_1$ of cadmium atoms is to be observed. The spectrometer has a resolution of 0.01 nm . The minimum magnetic field needed to observe this is

$(m_e = 9.1 \times 10^{-31}\ \text{kg}, e = 1.6 \times 10^{-19}\text{C}, c = 3 \times 10^8\ \text{m/s}\ )$

(A) 0.26 T

(B) 0.52 T

(C) 2.6 T

(D) 5.2 T

**Q37. [Marks: 2 | MCQ]** Atomic and Molecular Physics · Molecular Physics

| Gate 2013 | MCQ | 2M |
|---|---|---|

The spacing between vibrational energy levels in CO molecule is found to be $8.44 \times 10^{-2}$eV. Given that the reduced mass of CO is $1.14 \times 10^{-26}$ kg, Planck's constant is $6.626 \times 10^{-34}$Js and $1\text{eV} = 1.6 \times 10^{-19}$ J. The force constant of the bond in CO molecule is

(A) $1.87$ N/m

(B) $18.7$ N/m

(C) $187$ N/m

(D) $1870$ N/m

**Q38. [Marks: 2 | MCQ]** Solid State Physics · Crystallography

| Gate 2013 | MCQ | 2M |
|---|---|---|

A lattice has the following primitive vectors (in Å)

$$:\vec{a} = 2(\hat{\jmath} + \hat{k}), \vec{b} = 2(\hat{k} + \hat{\imath}), \vec{c} = 2(\hat{\imath} + \hat{\jmath})$$

The reciprocal lattice corresponding to the above lattice is

(A) BCC lattice with cube edge of $\left(\frac{\pi}{2}\right)$ Å$^{-1}$

(B) BCC lattice with cube edge of $(2\pi)$Å$^{-1}$

(C) FCC lattice with cube edge of $\left(\frac{\pi}{2}\right)$ Å$^{-1}$

(D) FCC lattice with cube edge of $(2\pi)$Å$^{-1}$

**Q39. [Marks: 2 | MCQ]** Solid State Physics · Lattice vibration

| Gate 2013 | MCQ | 2M |
|---|---|---|

The total energy of an ionic solid is given by an expression $E = -\frac{\alpha e^2}{4\pi\varepsilon_0 r} + \frac{B}{r^9}$ where $\alpha$ is Madelung constant, $r$ is the distance between the nearest neighbours in the crystal and $B$ is a constant. If $r_0$ is the equilibrium separation between the nearest neighbours then the value of $B$ is

(A) $\frac{\alpha e^2 r_0^8}{36\pi\epsilon_0}$

(B) $\frac{\alpha e^2 r_0^8}{4\pi\epsilon_0}$

(C) $\frac{2\alpha e^2 r_0^{10}}{9\pi\epsilon_0}$

(D) $\frac{\alpha e^2 r_0^{10}}{36\pi\epsilon_0}$

**Q40. [Marks: 2 | MCQ]** Quantum Mechanics · Potential Well

| Gate 2013 | MCQ | 2M |
|---|---|---|

A proton is confined to a cubic box, whose sides have length $10^{-12}$ m. What is the minimum kinetic energy of the proton? The mass of proton is $1.67 \times 10^{-27}$ kg and Planck's constant is $6.63 \times 10^{-34} Js$.

(A) $1.1 \times 10^{-17} J$

(B) $3.3 \times 10^{-17}$ J

(C) $9.9 \times 10^{-17}$ J

(D) $6.6 \times 10^{-17}$ J

**Q41. [Marks: 2 | NAT]** Mathematical Physics · Complex Analysis

| Gate 2013 | NAT | 2M |
|---|---|---|

For the function $f(z) = \frac{16z}{(z+3)(z-1)^2}$, the residue at the pole $z = 1$ is (your answer should be an integer) ___ .

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

| Gate 2013 | NAT | 2M |
|---|---|---|

The degenerate eigenvalue of the matrix

$$\begin{bmatrix} 4 & -1 & -1 \\ -1 & 4 & -1 \\ -1 & -1 & 4 \end{bmatrix}$$ is (your answer should be an integer) ___

**Q43. [Marks: 2 | NAT]** Nuclear and Particle Physics · Radioactivity

| Gate 2013 | NAT | 2M |
|---|---|---|

Consider the decay of a pion into a muon and an anti-neutrino $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$ in the pion rest frame.

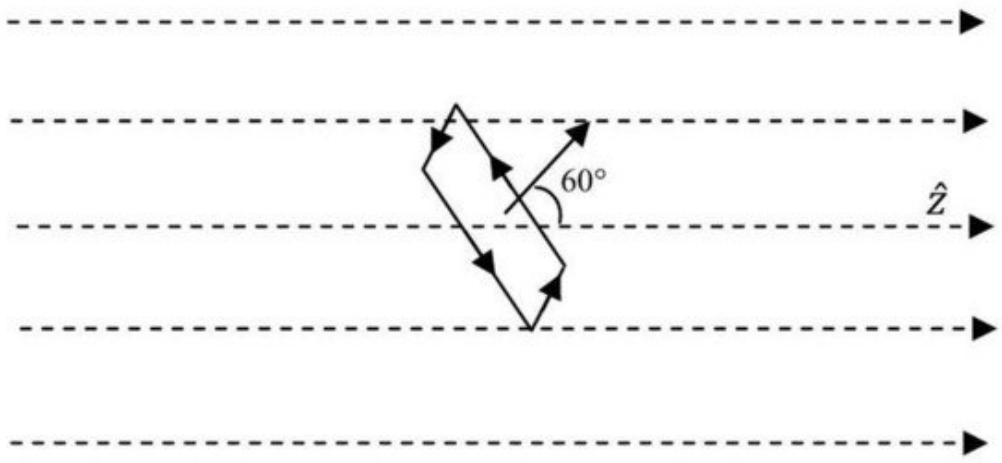
$$m_\pi = 139.6\text{MeV/c}^2, m_\mu = 105.7\text{MeV/c}^2, m_v \approx 0$$

The energy (in MeV ) of the emitted neutrino, to the nearest integer is ___

**Q44. [Marks: 2 | NAT]** Electromagnetism · Magnetism

| Gate 2013 | NAT | 2M |
|---|---|---|

In a constant magnetic field of 0.6 Tesla along the z direction, find the value of the path integral $\oint \vec{A} \cdot \overrightarrow{dl}$ in the units of (Tesla $\mathrm{m}^2$ ) on a square loop of side length ( $1/\sqrt{2}$ ) meters. The normal to the loop makes an angle of $60^\circ$ to the z-axis, as shown in the figure. The answer should be up to two decimal places. ___



**Q45. [Marks: 2 | NAT]** Quantum Mechanics · Spin and Total Angular momentum

| Gate 2013 | NAT | 2M |
|---|---|---|

A spin-half particle is in a linear superposition $0.8|\uparrow\rangle + 0.6|\downarrow\rangle$ of its spin-up and spin-down states. If $|\uparrow\rangle$ and $|\downarrow\rangle$ are the eigenstates of $\sigma_z$ then what is the expectation value, up to one decimal place, of the operator $10\sigma_z + 5\sigma_x$ ? Here, symbols have their usual meanings. ___

**Q46. [Marks: 2 | NAT]** Quantum Mechanics · Basics Quantum Mechanics

| Gate 2013 | NAT | 2M |
|---|---|---|

Consider the wave function $Ae^{ikr}(r_0/\mathrm{r})$, where $A$ is the normalization constant. For $r = 2r_0$ , the magnitude of probability current density up to two decimal places, in units of $\left(A^2\hbar k/m\right)$, is___ .

**Q47. [Marks: 2 | NAT]** Electronics · fet

| Gate 2013 | NAT | 2M |
|---|---|---|

An $n$-channel junction field effect transistor has $5m$ A source to drain current at shorted gate ( $I_{DSS}$ ) and 5 V pinch off voltage ( $V_P$ ). Calculate the drain current in $m$ A for a gate-source voltage ( $V_{GS}$ ) of -2.5 V . The answer should be up to two decimal places. ___

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

| Gate 2013 | MCQ | 2M |
|---|---|---|

There are four energy levels $E, 2E, 3E$ and $4E$ (where $E > 0$ ). The canonical partition function of two particles is, if these particles are

two identical fermions

(A) $e^{-2\beta E} + e^{-4\beta E} + e^{-6\beta E} + e^{-8\beta E}$

(B) $e^{-3\beta E} + e^{-4\beta E} + 2e^{-5\beta E} + e^{-6\beta E} + e^{-7\beta E}$

(C) $\left(e^{-\beta E} + e^{-2\beta E} + e^{-3\beta E} + e^{-4\beta E}\right)^2$

(D) $e^{-2\beta E} - e^{-4\beta E} + e^{-6\beta E} - e^{-8\beta E}$

**Q49. [Marks: 2 | MCQ]** Statistical Mechanics · Canonical ensemble

| Gate 2013 | MCQ | 2M |
|---|---|---|

There are four energy levels $E, 2E, 3E$ and $4E$ (where $E > 0$ ). The canonical partition function of two particles is, if these particles are

two distinguishable particles

(A) $e^{-2\beta E} + e^{-4\beta E} + e^{-6\beta E} + e^{-8\beta E}$

(B) $e^{-3\beta E} + e^{-4\beta E} + 2e^{-5\beta E} + e^{-6\beta E} + e^{-7\beta E}$

(C) $\left(e^{-\beta E} + e^{-2\beta E} + e^{-3\beta E} + e^{-4\beta E}\right)^2$

(D) $e^{-2\beta E} - e^{-4\beta E} + e^{-6\beta E} - e^{-8\beta E}$

**Q50. [Marks: 2 | MCQ]** Quantum Mechanics · Perturbation Theory

| Gate 2013 | MCQ | 2M |
|---|---|---|

To the given unperturbed Hamiltonian

$$\begin{bmatrix} 5 & 2 & 0 \\ 2 & 5 & 0 \\ 0 & 0 & 2 \end{bmatrix},$$

we add a small perturbation given by

$$\varepsilon \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & -1 \\ 1 & -1 & 1 \end{bmatrix}$$

where $\varepsilon$ is a small quantity.

The ground state eigenvector of the unperturbed Hamiltonian is

(A) $(1/\sqrt{2}, 1/\sqrt{2}, 0)$

(B) $(1/\sqrt{2}, -1/\sqrt{2}, 0)$

(C) $(0,0,1)$

(D) $(1,0,0)$

**Q51. [Marks: 2 | MCQ]** Quantum Mechanics · Perturbation Theory

| Gate 2013 | MCQ | 2M |
|---|---|---|

To the given unperturbed Hamiltonian

$$\begin{bmatrix} 5 & 2 & 0 \\ 2 & 5 & 0 \\ 0 & 0 & 2 \end{bmatrix},$$

we add a small perturbation given by

$$\varepsilon \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & -1 \\ 1 & -1 & 1 \end{bmatrix}$$

where $\varepsilon$ is a small quantity.

A pair of eigenvalues of the perturbed Hamiltonian, using first order perturbation theory, is

(A) $3 + 2\varepsilon, 7 + 2\varepsilon$

(B) $3 + 2\varepsilon, 2 + \varepsilon$

(C) $3, 7 + 2\varepsilon$

(D) $3, 2 + 2\varepsilon$

**Q52. [Marks: 2 | MCQ]** Nuclear and Particle Physics · Shell Model

| Gate 2013 | MCQ | 2M |
|---|---|---|

In the Schmidt model of nuclear magnetic moments, we have,

$$\vec{\mu} = \frac{e\hbar}{2Mc}\left(g_l\vec{l} + g_s\vec{S}\right)$$

where the symbols have their usual meaning

For the case $J = l + 1/2$, where $J$ is the total angular momentum, the expectation value of $\vec{S}\cdot\vec{J}$ in the nuclear ground state is equal to,

(A) $(J-1)/2$

(B) $(J+1)/2$

(C) $J/2$

(D) $-J/2$

**Q53. [Marks: 2 | MCQ]** Nuclear and Particle Physics · Shell Model

| Gate 2013 | MCQ | 2M |
|---|---|---|

In the Schmidt model of nuclear magnetic moments, we have,

$$\vec{\mu} = \frac{e\hbar}{2Mc}\left(g_l\vec{l} + g_s\vec{S}\right)$$

where the symbols have their usual meaning

For the $O^{17}$ nucleus ( $A = 17, Z = 8$ ), the effective magnetic moment is given by,

$$\vec{\mu}_{eff} = \frac{e\hbar}{2Mc}g\vec{J}$$

where $g$ is equal to, ( $g_s = 5.59$ for proton and -3.83 for neutron)

(A) 1.12

(B) -0.77

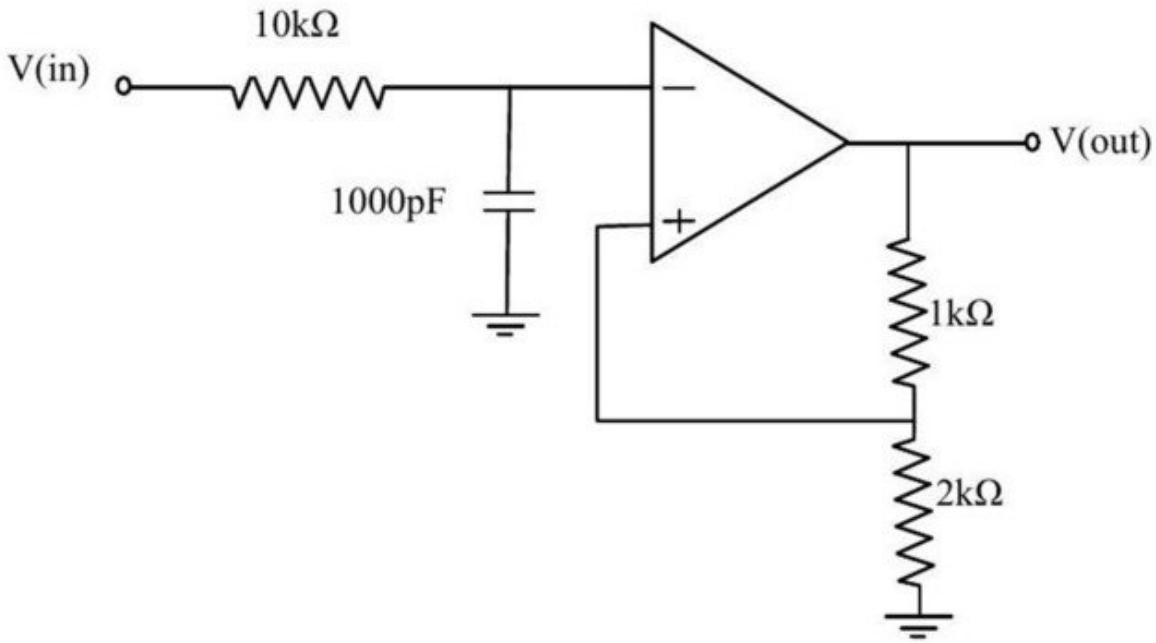
(C) -1.28

(D) 1.28

**Q54. [Marks: 2 | MCQ]** Electronics · OPAMP

| Gate 2013 | MCQ | 2M |
|---|---|---|

Consider the following circuit




For this circuit the frequency above which the gain will decrease by $20d$ B per decade is

(A) 15.9 kHz

(B) 1.2 kHz

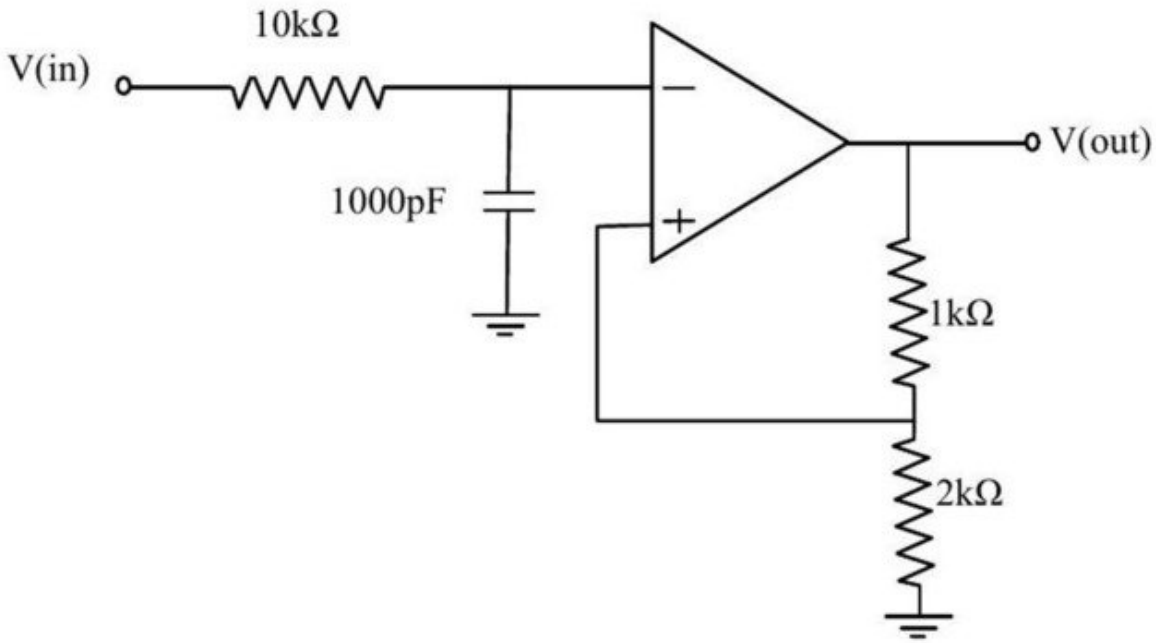
(C) 5.6 kHz

(D) 22.5 kHz

**Q55. [Marks: 2 | MCQ]** Electronics · OPAMP

| Gate 2013 | MCQ | 2M |
|---|---|---|

Consider the following circuit




At 1.2 kHz the closed loop gain is

(A) 1

(B) 1.5

(C) 3

(D) 0.5

**Q56. [Marks: 1 | MCQ]** General Aptitude · Mathematical Analysis

| Gate 2013 | MCQ | 1M |
|---|---|---|

A number is as much greater than 75 as it is smaller than 117 . The number is:

(A) 91

(B) 93

(C) 89

(D) 96

**Q57. [Marks: 1 | MCQ]** General Aptitude · English

| Gate 2013 | MCQ | 1M |
|---|---|---|

The professor ordered to the students to go out of the class.
I II III IV

Which of the above underlined parts of the sentence is grammatically incorrect?

(A) I

(B) II

(C) III

(D) IV

**Q58. [Marks: 1 | MCQ]** General Aptitude · English

| Gate 2013 | MCQ | 1M |
|---|---|---|

Which of the following options is the closest in meaning to the word given below:

Primeval

(A) Modern

(B) Historic

(C) Primitive

(D) Antique

**Q59. [Marks: 1 | MCQ]** General Aptitude · English

| Gate 2013 | MCQ | 1M |
|---|---|---|

Friendship, no matter how ___ it is, has its limitations.

(A) Cordial

(B) Intimate

(C) Secret

(D) pleasant

**Q60. [Marks: 1 | MCQ]** General Aptitude · English

| Gate 2013 | MCQ | 1M |
|---|---|---|

Select the pair that best expresses a relationship similar to that expressed in the pair:

Medicine: Health

(A) Science: Experiment

(B) Wealth: Peace

(C) Education: Knowledge

(D) Money: Happiness

**Q61. [Marks: 2 | MCQ]** General Aptitude · Mathematical Analysis

| Gate 2013 | MCQ | 2M |
|---|---|---|

X and Y are two positive real numbers such that $2X + Y \leq 6$ and $X + 2Y \leq 8$. For which of the following values of $(X, Y)$ the function $f(X, Y) = 3X + 6Y$ will give maximum value?

(A) $(4/3, 10/3)$

(B) $(8/3, 20/3)$

(C) $(8/3, 10/3)$

(D) $(4/3, 20/3)$

**Q62. [Marks: 2 | MCQ]** General Aptitude · Mathematical Analysis

| Gate 2013 | MCQ | 2M |
|---|---|---|

If $|4X - 7| = 5$ then the values of $2|X| - |-X|$ is:

(A) $2, 1/3$

(B) $1/2, 3$

(C) $3/2, 9$

(D) $2/3, 9$

**Q63. [Marks: 2 | MCQ]** General Aptitude · Data Analysis

| Gate 2013 | MCQ | 2M |
|---|---|---|

Following table provides figures (in rupees) on annual expenditure of a firm for two years - 2010 and 2011.

| **Category** | **2010** | **2011** |
|---|---|---|
| Raw material | 5200 | 6240 |
| Power & fuel | 7000 | 9450 |
| Salary & wages | 9000 | 12600 |
| Plant & machinery | 20000 | 25000 |
| Advertising | 15000 | 19500 |
| Research & Development | 22000 | 26400 |

In 2011, which of the following two categories have registered increase by same percentage?

(A) Raw material and Salary & wages

(B) Salary & wages and Advertising

(C) Power & fuel and Advertising

(D) Raw material and Research & Development

**Q64. [Marks: 2 | MCQ]** General Aptitude · Mathematical Analysis

| Gate 2013 | MCQ | 2M |
|---|---|---|

A firm is selling its product at Rs. 60 per unit. The total cost of production is Rs. 100 and firm is earning total profit of Rs. 500 . Later, the total cost increased by 30%. By what percentage the price should be increased to maintained the same profit level.

(A) 5

(B) 10

(C) 15

(D) 30

**Q65. [Marks: 2 | MCQ]** General Aptitude · Reasoning

| Gate 2013 | MCQ | 2M |
|---|---|---|

Abhishek is elder to Savar. Savar is younger to Anshul.

Which of the given conclusions is logically valid and is inferred from the above statements?

(A) Abhishek is elder to Anshul

(B) Anshul is elder to Abhishek

(C) Abhishek and Anshul are of the same age

(D) No conclusion follows

# Answer Key

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

| Q.No | Subject | Topic | Type | Marks | Answer |
|---|---|---|---|---|---|
| Q1 | Mathematical Physics | Fourier and Laplace transform | MCQ | 1 | **B** |
| Q2 | Mathematical Physics | Tensors | MCQ | 1 | **D** |
| Q3 | Classical Mechanics | Special theory of relativity | MCQ | 1 | **B** |
| Q4 | Statistical Mechanics | Quantum Statistical Mechanics | MCQ | 1 | **B** |
| Q5 | Thermodynamics | Phase transition | MCQ | 1 | **B** |
| Q6 | Thermodynamics | Laws of thermodynamics | MCQ | 1 | **A** |
| Q7 | Statistical Mechanics | Microcanonical ensemble | MCQ | 1 | **A** |
| Q8 | Statistical Mechanics | Microstates | MCQ | 1 | **D** |
| Q9 | Nuclear and Particle Phy… | Particle Physics | MCQ | 1 | **C** |
| Q10 | Nuclear and Particle Phy… | Particle Physics | MCQ | 1 | **D** |
| Q11 | Nuclear and Particle Phy… | Nuclear Force, deuteron problem an… | MCQ | 1 | **A** |
| Q12 | Nuclear and Particle Phy… | Radioactivity | MCQ | 1 | **C** |
| Q13 | Electromagnetism | Magnetism | MCQ | 1 | **D** |
| Q14 | Optics | Interference and Diffraction | MCQ | 1 | **B** |
| Q15 | Mathematical Physics | Vector Analysis | MCQ | 1 | **C** |
| Q16 | Optics | Polarization | MCQ | 1 | **C** |
| Q17 | Quantum Mechanics | Orbital angular momentum and hydr… | MCQ | 1 | **D** |
| Q18 | Classical Mechanics | Lagrangian and Hamiltonian | MCQ | 1 | **D** |
| Q19 | Electronics | AD/DA coversion | MCQ | 1 | **B** |
| Q20 | Solid State Physics | Semiconductor Physics | MCQ | 1 | **C** |
| Q21 | Solid State Physics | Superconductivity | MCQ | 1 | **C** |
| Q22 | Solid State Physics | Lattice vibration | MCQ | 1 | **B** |
| Q23 | Statistical Mechanics | Microstates | NAT | 1 | **70** |
| Q24 | Electronics | Diodes | NAT | 1 | **3.16** |
| Q25 | Atomic and Molecular Ph… | Effects in atomic physics | NAT | 1 | **3** |
| Q26 | Mathematical Physics | Fourier and Laplace transform | MCQ | 2 | **C** |
| Q27 | Mathematical Physics | Vector Analysis | MCQ | 2 | **B** |
| Q28 | Mathematical Physics | Gamma, Beta and Delta function | MCQ | 2 | **C** |
| Q29 | Electromagnetism | Relativistic EMT | MCQ | 2 | **C** |
| Q30 | Statistical Mechanics | Canonical ensemble | MCQ | 2 | **C** |
| Q31 | Nuclear and Particle Phy… | Nuclear properties | MCQ | 2 | **C** |
| Q32 | Classical Mechanics | Rotation Motion | MCQ | 2 | **C** |
| Q33 | Classical Mechanics | Small Oscillations | MCQ | 2 | **C** |
| Q34 | Electromagnetism | Electrostatics | MCQ | 2 | **A** |
| Q35 | Electromagnetism | EM Waves | MCQ | 2 | **C** |
| Q36 | Atomic and Molecular Ph… | Effects in atomic physics | MCQ | 2 | **B** |

# 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… | Molecular Physics | MCQ | 2 | **C** |
| Q38 | Solid State Physics | Crystallography | MCQ | 2 | **A** |
| Q39 | Solid State Physics | Lattice vibration | MCQ | 2 | **A** |
| Q40 | Quantum Mechanics | Potential Well | MCQ | 2 | **C** |
| Q41 | Mathematical Physics | Complex Analysis | NAT | 2 | **3** |
| Q42 | Mathematical Physics | Matrices | NAT | 2 | **5** |
| Q43 | Nuclear and Particle Phy… | Radioactivity | NAT | 2 | **30** |
| Q44 | Electromagnetism | Magnetism | NAT | 2 | **0.15** |
| Q45 | Quantum Mechanics | Spin and Total Angular momentum | NAT | 2 | **7.6** |
| Q46 | Quantum Mechanics | Basics Quantum Mechanics | NAT | 2 | **0.25** |
| Q47 | Electronics | fet | NAT | 2 | **1.25** |
| Q48 | Statistical Mechanics | Canonical ensemble | MCQ | 2 | **B** |
| Q49 | Statistical Mechanics | Canonical ensemble | MCQ | 2 | **C** |
| Q50 | Quantum Mechanics | Perturbation Theory | MCQ | 2 | **C** |
| Q51 | Quantum Mechanics | Perturbation Theory | MCQ | 2 | **C** |
| Q52 | Nuclear and Particle Phy… | Shell Model | MCQ | 2 | **B** |
| Q53 | Nuclear and Particle Phy… | Shell Model | MCQ | 2 | **B** |
| Q54 | Electronics | OPAMP | MCQ | 2 | **A** |
| Q55 | Electronics | OPAMP | MCQ | 2 | **B** |
| Q56 | General Aptitude | Mathematical Analysis | MCQ | 1 | **D** |
| Q57 | General Aptitude | English | MCQ | 1 | **B** |
| Q58 | General Aptitude | English | MCQ | 1 | **C** |
| Q59 | General Aptitude | English | MCQ | 1 | **B** |
| Q60 | General Aptitude | English | MCQ | 1 | **C** |
| Q61 | General Aptitude | Mathematical Analysis | MCQ | 2 | **A** |
| Q62 | General Aptitude | Mathematical Analysis | MCQ | 2 | **B** |
| Q63 | General Aptitude | Data Analysis | MCQ | 2 | **D** |
| Q64 | General Aptitude | Mathematical Analysis | MCQ | 2 | **A** |
| Q65 | General Aptitude | Reasoning | MCQ | 2 | **D** |