

PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Spin Angular momentum - CSIR NET Physics PYQs

Quantum Mechanics . All PYQs (2015-2025) with answer key

13 questions . Answer key included

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Q1. [Dec 2015] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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|----------|----------|-------|
| CSIR NET | 2015 Dec | 3.5 M |
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The Hamiltonian for a spin- $\frac{1}{2}$ particle at rest is given by $H = E_0(\sigma_z + \alpha\sigma_x)$, where σ_x and σ_z are Pauli spin matrices and E_0 and α are constants. The eigenvalues of this Hamiltonian are

1. $\pm E_0\sqrt{1 + \alpha^2}$
2. $\pm E_0\sqrt{1 - \alpha^2}$
3. E_0 (doubly degenerate)
4. $E_0 \left(1 \pm \frac{1}{2}\alpha^2\right)$

Q2. [Dec 2018] . 5.0 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2018 Dec | 5M |
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A system of spin $\frac{1}{2}$ particles is prepared to be in the eigenstate of σ_z with eigenvalue $+1$. The system is rotated by an angle of 60° about the x -axis. After the rotation, the fraction of the particles that will be measured to be in the eigenstate of σ_z with eigenvalue $+1$ is

1. $\frac{1}{3}$
2. $\frac{2}{3}$
3. $\frac{1}{4}$
4. $\frac{3}{4}$

Q3. [June 2018] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2018 June | 3.5M |
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The Hamiltonian of a spin $\frac{1}{2}$ particle in a magnetic field \vec{B} is given by $H = -\mu \cdot \vec{B} \cdot \vec{\sigma}$, where μ is a real constant and $\vec{\sigma} = (\sigma_x, \sigma_y, \sigma_z)$ are the Pauli spin matrices. If $\vec{B} = (B_0, B_0, 0)$ and the spin state at time $t = 0$ is an eigenstate of σ_x , then of the expectation values $\langle \sigma_x \rangle$, $\langle \sigma_y \rangle$ and $\langle \sigma_z \rangle$

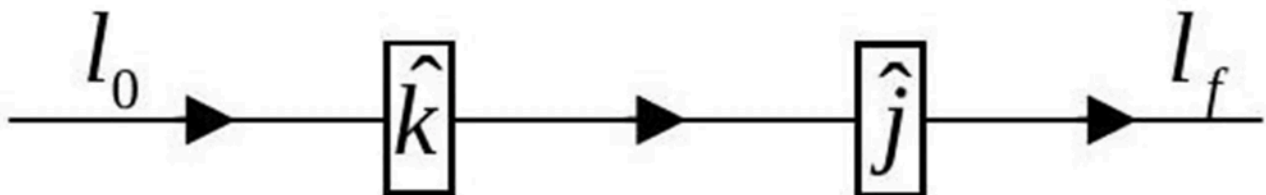
1. only $\langle \sigma_x \rangle$ changes with time
2. only $\langle \sigma_y \rangle$ changes with time
3. only $\langle \sigma_z \rangle$ changes with time
4. all three change with time

Q4. [June 2018] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2018 June | 3.5M |
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Two Stern-Gerlach apparatus S_1 and S_2 are kept in a line (x -axis). The directions of their magnetic fields are along the positive z and y -axes, respectively. Each apparatus only transmits particles with spins aligned in the direction of its magnetic field. If an initially unpolarized beam of spin $\frac{1}{2}$ particles passes through this configuration, the ratio of intensities $l_0:l_f$ of the initial and final beams is



1. 16:1
2. 2:1
3. 4:1
4. 1:0

Q5. [Dec 2019] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2019 Dec | 3.5M |
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The Hamiltonian of two interacting particles one with spin 1 and the other with spin $\frac{1}{2}$ is given by $H = A\vec{S}_1 \cdot \vec{S}_2 + B(S_{1x} + S_{2x})$, where \vec{S}_1 and \vec{S}_2 denote the spin operators of the first and second particles, respectively and A and B are positive constants. The largest eigenvalue of this Hamiltonian is

1. $\frac{1}{2}(A\hbar^2 + 3B\hbar)$
2. $3A\hbar^2 + B\hbar$
3. $\frac{1}{2}(3A\hbar^2 + B\hbar)$
4. $A\hbar^2 + 3B\hbar$

Q6. [June 2022] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2022 June | 3.5M |
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Consider the Hamiltonian $H = AI + B\sigma_x + C\sigma_y$, where A, B and C are positive constants, I is the 2×2 identity matrix and σ_x, σ_y are Pauli matrices. If the normalized eigenvector corresponding to its largest energy eigenvalue is $\frac{1}{\sqrt{2}} \begin{pmatrix} 1 \\ y \end{pmatrix}$, then y is

1. $\frac{B+iC}{\sqrt{B^2+C^2}}$
2. $\frac{A-iB}{\sqrt{A^2+B^2}}$
3. $\frac{A-iC}{\sqrt{A^2+C^2}}$
4. $\frac{B-iC}{\sqrt{B^2+C^2}}$

Q7. [June 2022] . 5.0 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2022 June | 5M |
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The Hamiltonian for a spin-1/2 particle in a magnetic field $\vec{B} = B_0 \hat{k}$ is given by $H = \lambda \vec{S} \cdot \vec{B}$, where \vec{S} is its spin (in units of \hbar) and λ is a constant. If the average spins density is $\langle \vec{S} \rangle$ for an ensemble of such non-interacting particles, then

$$\frac{d}{dt} \langle S_x \rangle$$

1. $\frac{\lambda}{\hbar} B_0 \langle S_x \rangle$

2. $\frac{\lambda}{\hbar} B_0 \langle S_y \rangle$

3. $-\frac{\lambda}{\hbar} B_0 \langle S_x \rangle$

4. $-\frac{\lambda}{\hbar} B_0 \langle S_y \rangle$

Q8. [Dec 2023] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2023 Dec | 3.5 M |
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The normalized wave function of an electron is

$$\psi(\vec{r}) = R(r) \left[\sqrt{\frac{3}{8}} Y_1^0(\theta, \varphi) \chi_- + \sqrt{\frac{5}{8}} Y_1^1(\theta, \varphi) \chi_+ \right]$$

where Y_l^m are the normalized spherical harmonics and χ_{\pm} denote the wavefunction for the two spin states with eigenvalues $\pm \frac{1}{2} \hbar$. The expectation value of the z component of the total angular momentum in the above state is

1. $-\frac{3}{4} \hbar$
2. $\frac{3}{4} \hbar$
3. $-\frac{9}{8} \hbar$
4. $\frac{9}{8} \hbar$

Q9. [Dec 2024] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2024 Dec | 3.5M |
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An electron is in the spin state $|\psi\rangle = \frac{1}{5} \begin{pmatrix} 3i \\ 4 \end{pmatrix}$ in the \hat{S}_z basis. A measurement of \hat{S}_x is made on this state. The probabilities of getting $\hbar/2$ and $-\hbar/2$ are

1. $\frac{1}{3}, \frac{2}{3}$
2. $\frac{1}{4}, \frac{3}{4}$
3. $\frac{1}{2}, \frac{1}{2}$
4. $\frac{3}{7}, \frac{4}{7}$

Q10. [Dec 2024] . 5.0 marks

Quantum Mechanics > Spin Angular momentum

CSIR NET

2024 Dec

5M

For a system of two electrons, define an operator

$$\hat{A} = \frac{3}{a^2} (\hat{S}_1 \cdot \vec{a}) (\hat{S}_2 \cdot \vec{a}) - \hat{S}_1 \cdot \hat{S}_2$$

where \vec{a} is an arbitrary vector, and \hat{S}_1 and \hat{S}_2 are spin operators. The eigenvalues of \hat{A} (in units of \hbar^2) are

1. $-1, 1, \frac{3}{2}, \frac{3}{2}$
2. $-1, -\frac{1}{2}, -\frac{1}{2}, 0$
3. $\frac{1}{2}, 1, \frac{3}{2}, \frac{3}{2}$
4. $0, \frac{1}{2}, \frac{1}{2}, -1$

Q11. [June 2024] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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| CSIR NET | 2024 June | 3.5M |
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If \vec{L} is the orbital angular momentum operator and $\vec{\sigma}$ are the Pauli matrices, which of the following operators commutes with $\vec{\sigma} \cdot \vec{L}$?

1. $\vec{L} - \frac{\hbar}{2} \vec{\sigma}$
2. $\vec{L} + \frac{\hbar}{2} \vec{\sigma}$
3. $\vec{L} + \hbar \vec{\sigma}$
4. $\vec{L} - \hbar \vec{\sigma}$

Q12. [Dec 2025] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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|----------|----------|------|----|
| CSIR NET | 2025 Dec | 3.5M | QM |
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A spin- $\frac{1}{2}$ particle is in a magnetic field $\vec{B} = B_x \hat{x} + B_y \hat{y}$ for which the spin dependent Hamiltonian is $\hat{H} = -A \hat{S} \cdot \vec{B}$ (A is a positive constant and \hat{S} is the spin-operator). The eigenvalues of the Hamiltonian are

1. $\pm A \frac{\hbar}{2} (B_x + B_y)$
2. $\pm A \frac{\hbar}{2} \sqrt{B_x B_y}$
3. $\pm A \frac{\hbar}{2} (B_x^2 + B_y^2)^{\frac{1}{2}}$
4. 0

Q13. [June 2025] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

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|----------|-----------|------|----|
| CSIR NET | 2025 June | 3.5M | QM |
|----------|-----------|------|----|

A spin- $\frac{1}{2}$ system is prepared in the initial state $|\varphi\rangle = \frac{\sqrt{3}}{2} |\uparrow\rangle + \frac{1}{2} |\downarrow\rangle$ where $|\uparrow\rangle$ & $|\downarrow\rangle$ are eigenstates of \hat{S}_z with eigenvalues $+\frac{\hbar}{2}$ & $-\frac{\hbar}{2}$ respectively. A measurement of \hat{S}_z is followed by a measurement of \hat{S}_x on the system. What is the probability that the measurement of \hat{S}_x yields a value $+\frac{\hbar}{2}$?

1. $\frac{1}{2}$
2. $\frac{2+\sqrt{3}}{4}$
3. $\frac{2-\sqrt{3}}{4}$
4. $\frac{3}{8}$

Answer Key

13 questions . Subject and topic for quick revision

| Q. No | Subject | Topic | Answer |
|-------|-------------------|-----------------------|--------|
| Q1 | Quantum Mechanics | Spin Angular momentum | 1 |
| Q2 | Quantum Mechanics | Spin Angular momentum | 4 |
| Q3 | Quantum Mechanics | Spin Angular momentum | 4 |
| Q4 | Quantum Mechanics | Spin Angular momentum | 3 |
| Q5 | Quantum Mechanics | Spin Angular momentum | 1 |
| Q6 | Quantum Mechanics | Spin Angular momentum | 1 |
| Q7 | Quantum Mechanics | Spin Angular momentum | 4 |
| Q8 | Quantum Mechanics | Spin Angular momentum | 2 |
| Q9 | Quantum Mechanics | Spin Angular momentum | 3 |
| Q10 | Quantum Mechanics | Spin Angular momentum | 4 |
| Q11 | Quantum Mechanics | Spin Angular momentum | 2 |
| Q12 | Quantum Mechanics | Spin Angular momentum | 3 |
| Q13 | Quantum Mechanics | Spin Angular momentum | 1 |

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