1. Starting from the classical definition of magnetic moment, derive the quantum mechanical operator form using the Bohr magneton.
2. An electron is in an orbital with angular momentum quantum number l=2. Represent the orbital angular momentum using vector model along with its projection along z-axis.
3. An atom has S = 1, L = 2, and J = 3. Calculate the Landé g-factor and the magnetic moment.
4. Why the magnetic moment operator is not generally aligned with the total angular momentum vector in the presence of spin-orbit coupling? Explain using vector model.