B.Tech 1st Year IT - Quantum Mechanics & Linear Algebra Notes

Short Notes

MODULE 1 - QUANTUM PHYSICS BASICS
Wave-Particle Duality: Quantum objects show both particle-like and wave-like properties.
Young's Double Slit: Interference without observation; particle pattern with observation.
Need for QM: Explains atomic structure, spectra, blackbody, photoelectric, Compton effects.
Blackbody: E=hnu, energy quantized.
Compton Effect: Deltalambda = (h/m_ec)(1 - cos theta).
de Broglie: lambda = h/p.
Wave Function: |psi| = probability density, normalized |psi| dV = 1.
Uncertainty: DeltaxDeltap hbar/2; DeltaEDeltat hbar/2.
Schrdinger: TDSE, TISE equations.
Stern-Gerlach: Spin quantization hbar/2.

MODULE 2 - LINEAR ALGEBRA FOR QM
Vector Spaces: Closure, associativity, distributivity, identity.
Basis: Linearly independent set spanning space.
Orthonormal Sets: Orthogonal & normalized.
Hilbert Space: Complete inner product space.
Dirac Notation: Ket |psi>, Bra <psi|, Inner & Outer products.
Operators: Hermitian (real eigenvalues), Unitary (UU=I), Projection (P=P).
Eigenvalues: Apsi = lambdapsi.

Formula Sheet

Planck's quantum: E = hnu
de Broglie wavelength: lambda = h/p = h/sqrt(2mE)
Bragg's Law: nlambda = 2d sin theta
Compton shift: Deltalambda = (h/m_ec)(1 - cos theta)
Normalization: |psi| dV = 1
Uncertainty: DeltaxDeltap hbar/2, DeltaEDeltat hbar/2
TDSE: ihbar psi/t = -(hbar/2m) psi + Upsi
Inner product: <phi|psi> = phi* psi
Outer product: |psi><phi|
Eigenvalue: Apsi = lambdapsi

Theory Questions

1. Explain wave-particle duality with Young's experiment.
2. Discuss Davisson-Germer experiment and significance.
3. Define blackbody radiation and Planck's quantization.
4. Explain Compton effect with derivation.
5. Derive de Broglie wavelength and Bohr's quantization.
6. State and explain Born interpretation of psi.
7. Derive uncertainty relations.
8. Write TDSE and TISE and explain.
9. Discuss Stern-Gerlach experiment.
10. Define vector space, basis, dimension.
11. Explain Hilbert space with example.
12. Define Hermitian, Unitary, Projection operators.
13. Dirac notation: ket, bra, inner, outer products.
14. Explain eigenvalue equation in QM.

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Numerical Problems

1. lambda for neutron at 2x10 m/s.
2. Electron wavelength at 200 V.
3. Compton shift for lambda=0.1nm at theta=45.
4. Bullet Deltax from Deltav=0.001 m/s, m=0.05 kg.
5. Electron Deltav from Deltax=1 nm.
6. Normalize psi(x) = A x e^{-alphax}, x0.
7. Normalize psi(x) = N sin(npix/L), 0xL.
8. Show |psi> = (1/sqrt3)(|0> + i|1> + |2>) normalized.
9. Compute |psi><psi| for above.
10. Check if H = [[2,i],[-i,3]] is Hermitian.
11. Eigenvalues/vectors of A = [[4,1],[1,4]].
12. Verify U = (1/sqrt2)[[1,1],[-1,1]] is unitary.
13. Show (1,2) & (3,1) independent.
14. Expand (3,1) in orthonormal basis (1,1)/sqrt2, (1,-1)/sqrt2.