P-105: Quantum Mechanics I

Syllabus:

1. *Wave mechanics*: wave-particle duality, wavefunctions and wave groups, expectation values, bra-ket notation (linear algebra not required), uncertainty principle, Schrödinger equation, free particles, box normalisation, bound and scattering states, boundary conditions, completeness hypothesis, correspondence and complementarity

2. *One-dimensional bound state problems*: particle bound in box, square well, delta function and harmonic oscillator potentials, Krönig-Penney model; scattering from a one-dimensional step, square barrier and delta function potentials, matrix methods for piecewise constant potentials.

3. *Three-dimensional bound state problems*: particle in a box, phase space and Jeans number, central potentials, orbital angular momentum, H atom, spherical oscillator.

4. *Discrete symmetries in quantum mechanics*: parity, time-reversal, particle exchange operator, identical particles, Bose and Fermi statistics, multi-particle wavefunctions: Slater determinant.

5. *Time-independent perturbation theory* : Rayleigh-Schrödinger expansion, orders of perturbation theory, non-degenerate states: energy and state corrections in the first order, Zeeman and Paschen-Back effect, energy and state corrections to the second order, Dalgarno-Lewis operators, degenerate states : Stark effect in hydrogen.

6. *Variational methods:* Rayleigh-Ritz theorem, helium atom, method of variation of coefficients, hydrogen molecular ion and LCAO approximation, hydrogen molecule, Heitler-London approximation, bonding and antibonding orbitals.

Special Topics:

1. *WKB approximation*: eikonal approximation, semiclassical reduction of Schrödinger equation, WKB equation, solution to quadrature, validity of WKB solution, turning points and connection formulae, bound state solutions in the WKB approximation, Bohr-Sommerfeld quantisation condition, barrier penetration.

Recommended Textbooks:

1. J. J. Sakurai : Modern Quantum Mechanics (Addison Wesley)
2. Cohen-Tannoudji : Quantum Mechanics (John Wiley and Sons)
3. E. Merzbacher : Quantum Mechanics (John Wiley and Sons)
4. R. Shankar : Principles of Quantum Mechanics (Springer)
5. K. Gottfried and T-M Yan: Quantum Mechanics : Fundamentals (Springer)