Synopsis: (mostly revision) Lectures 1-4ish

1. **Foundations of quantum physics:**

   †Historical background; wave mechanics to Schrödinger equation.

2. **Quantum mechanics in one dimension:**

   Unbound particles: potential step, barriers and tunneling; bound states: rectangular well, δ-function well; †Kronig-Penney model .

3. **Operator methods:**

   Uncertainty principle; time evolution operator; Ehrenfest's theorem; †symmetries in quantum mechanics; Heisenberg representation; quantum harmonic oscillator; †coherent states.

4. **Quantum mechanics in more than one dimension:**

   Rigid rotor; angular momentum; raising and lowering operators; representations; central potential; atomic hydrogen.

† non-examinable *in this course*.

Synopsis: Lectures 5-10

5. **Charged particle in an electromagnetic field:**

   Classical and quantum mechanics of particle in a field; normal Zeeman effect; gauge invariance and the Aharonov-Bohm effect; Landau levels, †Quantum Hall effect.

6. **Spin:**

   Stern-Gerlach experiment; spinors, spin operators and Pauli matrices; spin precession in a magnetic field; parametric resonance; addition of angular momenta.

7. **Time-independent perturbation theory:**

   Perturbation series; first and second order expansion; degenerate perturbation theory; Stark effect; nearly free electron model.

8. **Variational and WKB method:**

   Variational method: ground state energy and eigenfunctions; application to helium; †Semiclassics and the WKB method.

† non-examinable *in this course*.

Synopsis: Lectures 11-15

9. **Identical particles:**

   Particle indistinguishability and quantum statistics; space and spin wavefunctions; consequences of particle statistics; ideal quantum gases; †degeneracy pressure in neutron stars; Bose-Einstein condensation in ultracold atomic gases.

10. **Atomic structure:**

    Relativistic corrections – spin-orbit coupling; Darwin term; Lamb shift; hyperfine structure. Multi-electron atoms; Helium; Hartree approximation †and beyond; Hund's rule; periodic table; LS and jj coupling schemes; atomic spectra; Zeeman effect.

11. **Molecular structure:**

    Born-Oppenheimer approximation; H_2^+ ion; H_2 molecule; ionic and covalent bonding; LCAO method; from molecules to solids; †application of LCAO method to graphene; molecular spectra; rotation and vibrational transitions.

† **non-examinable *in this course*.**

Synopsis: Lectures 16-19

12. **Field theory: from phonons to photons:**

    From particles to fields: classical field theory of harmonic atomic chain; quantization of atomic chain; phonons; classical theory of the EM field; †waveguide; quantization of the EM field and photons.

13. **Time-dependent perturbation theory:**

    Rabi oscillations in two level systems; perturbation series; sudden approximation; harmonic perturbations and Fermi's Golden rule.

14. **Radiative transitions:**

    Light-matter interaction; spontaneous emission; absorption and stimulated emission; Einstein's A and B coefficents; dipole approximation; selection rules; lasers.

† non-examinable *in this course*.

Synopsis: Lectures 20-24

15. **Scattering theory**

    †Elastic and inelastic scattering; †method of particle waves; †Born series expansion; Born approximation from Fermi's Golden rule; †scattering of identical particles.

16. **Relativistic quantum mechanics:**

    †Klein-Gordon equation; †Dirac equation; †relativistic covariance and spin; †free relativistic particles and the Klein paradox; †antiparticles; †coupling to EM field: †minimal coupling and the connection to non-relativistic quantum mechanics; †field quantization.

† non-examinable *in this course*.