Solid State Physics

1. Crystal lattices and phonons
   - Crystal lattice, symmetries, Bravais lattices. Diffraction theory, structure factor, elastic scattering experiments. Quasi crystals, amorphous solids.
   - Dispersion relation in harmonic approximation, acoustic and optical branches.
   - Quantum theory of phonons. Energy and quasi-momentum. Inelastic scattering experiments.
   - Density of states, specific heat. Debye model.
2. Band structure and dynamics
   - Bloch theorem, band structure. Spectrum in weak coupling and tight binding approximations. Effective mass tensor.
   - Quasi-classical dynamics of Bloch electrons.
   - Landau levels, magnetic oscillations. Landau diamagnetism. Experimental determination of the Fermi surface. Quantum Hall effect.
3. Linear response
   - Linear response. Transport processes and coefficients, cross-effects, Onsager's reciprocity relations, Thomson relation. Causality, Kramers-Kronig relation.
   - Dissipative and elastic response, spectral resolution. Scattering experiments.
   - Kubo formula. Classical limit. Frequency dependent electric conductivity, Drude formula.
4. Transport
   - Boltzmann equation. Collision term, relaxation time approximation. Electric and heat conductivity, mean free path, mobility. Magnetoresistance, Seebeck- and Peltier-effects.
   - Electron-impurity interaction. Perturbation theory for impurities, transition probability, transport life time.
   - Electron-phonon interaction. Deformation potential approximation, electron-phonon scattering processes, conservation laws. Temperature dependence of resistivity in metals.
5. Magnetism
   - Ferromagnetism of metals: Zeeman energy, Pauli susceptibility, mean field approximation, Stoner formula.
   - Localized magnetic moments, Hund's rules, Curie, van Vleck and Larmor susceptibilities.
   - Hubbard model, Mott transition, Heisenberg model, spin-wave theory.
6. Electron interactions
   - Lifetime of interacting electrons.
   - Charge and spin susceptibility of metals in mean field approximation, spectrum of excitations, collective modes.
   - Screening, induced charge, Friedel oscillations, Kohn anomaly.
   - Dynamic screening, plasmon oscillations, reflectivity of metals.
   - Hartree-Fock approximation, interacting free electron spectrum, metallic bonding, Wigner crystal.
7. Semiconductors
   - Crystal and band structure of semiconductors, its formation and characteristics (Ge, Si, GaAs), cyclotron resonance.
   - Charge carriers in intrinsic/extrinsic semiconductors, shallow donor and acceptor levels.
   - Semiconductor devices: p-n junction, diode, diffusion, transistor, field-effect transistor, tunnel diode, semiconductor laser, LED.
8. Superconductivity
   - Phenomenology of type I and type II superconductors, Meissner effect, London equation.
   - Cooper pairs, BCS theory, flux quantisation.
   - Ginzburg-Landau theory of type II superconductors, Abrikosov vortices.
   - Superconducting tunnel junctions. DC and AC Josephson effect. SQUIDs.
   - High temperature superconductors.

Recommended MSc courses

BMETE11MF41 Modern Solid State Physics
BMETE12MF26 Physics of Semiconductors
BMETE11MF45 Superconductivity
BMETE15MF44 Statistical Physics 2
BMETE11MF44 Theory of Magnetism

Recommended literature

- Jenő Sólyom: Fundamentals of the Physics of Solids I-III (Springer, Berlin, 2007-2010), es
- Patrik Fazekas: Lecture Notes on Electron Correlation and Magnetism (World Scientific, Singapore, 1999).