

Condensed Matter Theory. Spring semester 2015.
List of exam topics.

1. Specific heat of electrons and phonons.

$$c_e \propto T, \quad c_{\text{ph}} \propto T^3$$

2. Irreducible representations of groups and degeneracies in the electron band structure.

$$\text{degeneracy} = \dim \Gamma$$

3. Hartree–Fock exchange energy for interacting electrons.

$$\delta E = -\frac{\mathcal{V}}{2} \iint \frac{d^3 k}{(2\pi)^3} \frac{d^3 k'}{(2\pi)^3} n_k n_{k'} V_{k-k'}$$

4. Time-ordered Green's functions for noninteracting and interacting electrons. Self energy.

$$G^c(t_1 - t_2; x_1, x_2) = -iT \langle a(t_1, x_1) a^\dagger(t_2, x_2) \rangle,$$

$$G_{\text{free}}^c(\omega, k) = \frac{1}{\omega - (\varepsilon_k - \mu) + i\delta \operatorname{sign} \omega},$$

$$G_{\text{int}}^c(\omega, k) = \frac{1}{\omega - (\varepsilon_k - \mu) - \Sigma(\omega, k) + i\delta \operatorname{sign} \omega}$$

5. Thomas–Fermi and Lindhard screening of Coulomb interaction.

$$\phi(R) = \frac{Q}{R} e^{-\kappa R}, \quad \kappa = (4\pi e^2 \nu_0)^{1/2}, \quad \phi(q) = \frac{Q}{\frac{q^2}{4\pi} - e^2 \chi(q)}$$

6. BCS theory: superconducting quasiparticles and their spectrum.

$$\gamma_{k\uparrow}^+ = u_k a_{k\uparrow}^+ + v_k a_{-k\downarrow}, \quad \tilde{\varepsilon}_k = \pm \sqrt{(\varepsilon_k - \mu)^2 + |\Delta|^2}$$

7. BCS theory: relation between superconducting transition temperature and the gap at zero temperature.

$$T_c/\Delta_0 \sim 0.57$$