1. Consider a semiconductor with the intrinsic carrier concentration \( N_i \). Derive a formula for the Thomas-Fermi screening radius \( R_{TF} \) at a given temperature \( T \). Hint: consider the equilibrium state in the presence of an external potential \( \phi(r) \), write down expressions for the electron and hole densities as a function of \( r \), the Gauss law, and collect terms linear in \( \phi \). Don't forget the dielectric constant \( K \).

2. Estimate \( R_{TF} \) for Ge, \( N_i = 2.4 \times 10^{13} \text{cm}^{-3} \), \( T = 300 \text{K} \), \( K = 16.2 \).

3. Do the same for Ge doped with \( N_D = 10^{17} \text{cm}^{-3} \) donor impurities.

4. An experimentally measured conductivity of some metal was fitted to a Lorentzian: \( \text{Re} \sigma(\omega) = \sigma(0)/(1 + \omega^2/\omega_0^2) \) with parameters \( \sigma(0) = 10^5 \Omega^{-1} \text{cm}^{-1} \), \( \hbar \omega_0 = 10 \text{meV} \). Estimate the carrier concentration and the plasma frequency (in Hz). Note that \( 1 \text{s}^{-1} = \frac{1}{2\pi} \text{Hz} \).

5. A number of insulating crystals strongly reflect incident radiation in a fairly narrow range of wavelengths, \( \lambda_1 < \lambda < \lambda_2 \). Explain this effect appealing to the diagram of collective excitations in such a material. Find the \( \lambda_2/\lambda_1 \) ratio for ZnTe based on its static dielectric constant \( K = 9.86 \) and the refraction index \( N = 2.70 \).

6. Derive the functional dependence of the magnetization \( \mu \) of a ferromagnet on a weak external magnetic field \( H \) above and at the transition temperature based on the Landau theory of phase trans. Introduce your own notations for the requisite phenomenological coefficients.

7. Calculate the supercurrent density \( \mathbf{j} \) at the surface of a long superconducting cylinder of radius \( R = 1 \text{mm} \) subject to a uniform magnetic field \( H = 1000 \text{G} \) parallel to its axis. London penetration length \( \xi \) is \( \xi = 2 \text{µm} \). Give the answer both in CGS and A/m² units.