Physics 861 – Fall 01
Problem set 2 - Due Tuesday, Sep. 18

1.

Problem 1, page 53, of Ashcroft and Mermin.

2.

Solve the Schrödinger equation for an electron in crossed electric and magnetic fields. Take the magnetic field along z and the electric field along x. Use the Landau gauge.

3. Two-band formulas

(a) Recall the elementary derivation of the Drude formula for the conductivity, $\sigma = ne^2\tau/m$. What if there are several types of charge carriers? Suppose that there are n_k carriers of mass m_k, charge e_k, collision time τ_k and show that $\sigma = \sum_k \sigma_k$, where σ_k is the Drude conductivity when only the carriers of type k are present.

(b) Recall that the Drude theory predicts that the Hall coefficient is $-1/ne$ [SI], or $-1/nec$ [Gauss], and the conductivity is unchanged by the application of a magnetic field. Find the Hall coefficient $R = E_y/j_xB$ when there are two types of carriers.

Your task is to obtain AM's Eq. (12.73), starting from equations like AM's (1.19) for each carrier. It is probably best to introduce $\rho_k = 1/\sigma_k$ and $\omega_k\tau_k/\sigma_k = -R_kB$ [SI] $= -R_kB/c$ [Gauss] from the beginning.

The experimental constraint of the Hall measurement is that $j_y = 0$, which allows for "counterflow" when there are two or more carrier types. That is why the Hall phenomena are so complex when more than one carrier type is present.

Alternate.

Problem 2, page 53, of Ashcroft and Mermin.