Physics 861 { Fall 01
Problem set 1- Due Tuesday, Sep. 11

1.

Ashcroft and Mermin's problem 1, page 25. This is the notorious \hitchhiker's paradox", which you can look up in books on statistics. On the web, a good reference is http://keskus.hut.¯/opetus/s38143/2000/luennot/E_lect06.pdf, page 14. For full credit you should answer the question in part (e), what is the probability distribution p(T).

2.

Consider a wire of length l and cross-sectional area A, with conductivity ¾ given by Drude's formula (at ¯nite !). Show that this wire is equivalent to a circuit containing a resistance R and an inductance L_k, called the kinetic inductance. Are R and L_k in series or in parallel? Find SI values for R and L_k when the wire is made of copper, A = 1 mm^2 and l = 1 m. Compare L_k with the ordinary inductance L of the same wire, assuming it to be the inner conductor of a coaxial cable of cross-sectional area 1 cm^2. (This will give the right magnitude of L for any reasonable circuit containing the wire.)

3.

Ashcroft and Mermin's problem 5, page 27. For part (b), you should produce an accurate plot of ! vs. qc (for positive q and !), using the computer package of your choice. The lower branch of this curve is known as the surface plasmon-polariton. You can look at books, but you should use AM's notation to show that you did the problem yourself.

Hints. There are 7 unknowns: the four amplitudes A; B; C; D and the three wave vector components q; K; K^0. However, the overall amplitude of the wave is arbitrary, so you will need six equations: two for the ¯eld components in the metal, two for the ¯eld components in vacuum, and two boundary conditions. For the ¯elds, use the divergence equation and the wave equation (if you do this, you will not need to worry about magnetic ¯elds). For part (a), you do not need to put in the explicit Drude formula for "; just work with a generic " that depends on !.

4.

What is the Hall coe±cient of Aluminum in a very weak B ¯eld? Does it agree (in sign and magnitude) with the Drude model for a chemical valence of 3? For what value of the Hall angle does R_H change sign in Al?

Alternative.

If " is given, at least approximately, by Drude's formula, show that the Fresnel re-°ection coe±cient for p-polarized radiation has a pole at the surface plasmon-polariton frequency. Show explicitly for small 1=¿ that this pole is in the lower half plane of !..Why, physically, there is no such pole for s-polarization?

Hints. The electric ¯eld is in the plane of incidence for p-polarization (also called vertical polarization). It is perpendicular to the plane of incidence for s-polarization (also called horizontal polarization). You can generalize problem 3 to compute the Fresnel coe±cients, or just take them from Jackson and change over to AM notation.