Physics 4243/5243
Problem Set #3
Due Friday February 6th

Problem 1:
a) Calculate the 1-D and 2-D analogues to equations 4.3, 4.6, 4.7 and 4.10 in Simon

b) Sketch the density of states in 1, 2 and 3D.

Problem 2: Simon 4.2

Problem 3: Simon 4.7

For Graduate Students only (5243):
Problem 4: Taken from Kittel
A metal with a concentration n of free electrons of charge –e is in a static magnetic field, $Bz\hat{}$. The electric current density in the *xy* plane is related to the electric field by

$$j_x = \sigma_{xx} E_x + \sigma_{xy} E_y \; ; \; j_y = \sigma_{yx} E_x + \sigma_{yy} E_y$$

Assume that the frequency $\omega >> \omega c$ and $\omega >> 1/\tau$ , where $\omega c \equiv eB/m$ and $\tau$ is the collision time.

(a) Solve the drift velocity equation to find the components of the magnetoconductivity tensor:

$$\sigma_{xx} = \sigma_{yy} = i\omega_p^2 / 4\pi\omega \quad ;$$

$$\sigma_{xy} = -\sigma_{yx} = \omega_c \omega_p^2 / 4\pi\omega^2$$

where $\omega_p^2 \equiv 4\pi ne^2/m$

(b) Note from a Maxwell equation [$c^2\nabla^2 E = \varepsilon \partial^2 E/\partial^2 t$] that the dielectric function tensor of the medium is related to the conductivity tensor as $\varepsilon = 1 + i(4\pi/\omega)\sigma$ . Consider an electromagnetic wave with wavevector $k = kz\hat{}$. Show that the dispersion relation for this wave in the medium is

$$c^2k^2 = \omega^2 - \omega_p^2 \pm \omega_c \omega_p^2/\omega$$

At a given frequency there are two modes of propagation with different wavevectors and different velocities. The two modes correspond to circularly polarized waves. Because a linearly polarized wave can be decomposed into two circularly polarized waves, it follows that the plane of polarization of a linearly polarized wave will be rotate by the magnetic field.