Physics 240B: Homework Problem Set 6
Due: March xx, 2008

1. Electrons in a Magnetic Field. 25 points.
We are considering electrons in magnetic fields. Since no interactions between electrons are being considered just now, we can consider each electron separately. The Hamiltonian for an electron in a magnetic field is

$$\mathcal{H} = \frac{1}{2m}[\vec{p} + \frac{e}{c}\vec{A}(\vec{r})]^2 + 2\mu_B \vec{S} \cdot \vec{B}.$$

Consider a constant magnetic field described by the vector potential $\vec{A} = -(1/2)\vec{r} \times \vec{B}$.
(i) Do the algebra to show that the Hamiltonian becomes

$$\mathcal{H} = \frac{(\vec{p})^2}{2m} + \mu_B(\vec{L} + 2\vec{S}) \cdot \vec{B} + \frac{1}{2}m(\frac{eB}{2mc})^2(x^2 + y^2).$$

(ii) Describe the eigenfunctions (equivalently, eigenstates) of this Hamiltonian complete with all quantum numbers, and give the expression for the eigenvalues and how they depend on the quantum numbers.

2. Landé g-factor. 10 points.
(i) Fill in the steps starting with Eq. (25.17) in Marder and obtain the expression (25.20) for the Landé g-factor $g(LSJ)$.
(ii) For an open f-shell f^n for n=1,....,13, calculate the g-factor and plot it versus n to observe the variation across the series. It's worthwhile to write a tiny program to do this for you.

3. Hund's Rules for p shell Electrons. 15 points.
(i) Work out the Hund's rule ground states for an open p-shell in an atom or ion, $p^n, n = 1, 2, 3, 4, 5$.
(ii) Give the spectroscopic notation for each one.
(iii) Use the code you wrote for Prob. 2(ii) to calculate the g-factor for each of these configurations; plot (a simple sketch is fine, as it is only 5 points) and compare with the f shell of Prob. 2(ii).