1. For J=1→J' transitions with J'=0,1, and 2, explicitly find the relative changes in populations of the J=1 Zeeman sublevels as a result of a single optical pumping cycle with linearly polarized light (assume quantization axis along the axis of polarization). Verify that in the first two cases, optical pumping leads to reduced light absorption (bleaching), while in the third case, the opposite is true: absorption increases as a result of optical pumping. Assume "closed" transitions, i.e. the lower state is the only decay branch.

2. Consider a uniformly magnetized sphere of radius R. Imagine a sphere of a radius $r \ll R$ inside of it. What is the magnetic field that the small sphere "sees?" This problem is relevant to optical pumping magnetometers utilizing magnetic resonance in oriented atoms contained in a vapor cell.

3. Suppose that one is measuring electric field strength by determining the quadratic Stark shift of a given atomic energy level. Suppose for concreteness that the field is E»10 kV/cm, and the Stark shift Δ_S can be measured to an absolute uncertainty $\delta\Delta_S$, corresponding to $\delta\Delta_S/\Delta_S(10\ \text{kV/cm})=10^{-4}$. a) What is the uncertainty δE in the determination of E ? b) What is the smallest field E^* that can be measured given this sensitivity $\delta\Delta_S$ to Stark shifts?

4. Calculate Landé factors and Larmor precession frequencies for $^2S_{1/2}$ atomic states (e.g., the ground electronic states of hydrogen and alkali atoms). Include the effect of the nuclear spin I, but ignore the interaction of the nuclear magnetic moment with the external magnetic field. Give qualitative explanations of a) the relative sign of the frequencies for the states with the total angular momentum $F=I\pm1/2$, and b) the relative magnitudes of the Larmor frequencies for atoms with different values of I.