HW#2

1) Assume you have a spherical magnetic particle that is 4-nm in diameter with a uniaxial anisotropy $K_U=5x10^6$ ergs/cm^3 and a moment of 1000 emu/cm^3.

a) Is this particle superparamagnetic at room temperature?

b) If a 0.05 T field is applied along the anisotropy axis what is the difference of the energy if the magnetization is parallel to the applied field vs. antiparallel to the field?

c) If a 0.05 T field is applied along the anisotropy axis what is the probability that the magnetization will be along the field axis and what is the probability is antiparallel to the field (this assumes that the magnetization is always along the anisotropy axis)?

d) Redo (b) and (c) for a 1.0-T applied field.

e) If the particle magnetization is parallel to the applied field, what is the expected ferromagnetic resonance frequency in a field of 0.05 and 1.0 T?

2) For a Ni wire described in HW1 what is the ferromagnetic resonant frequency in zero applied field?

3) For a thin-film of Fe: (a) what applied field is required to saturate the magnetization perpendicular to the film? (b) For the applied fields above the saturation field how does the ferromagnetic resonance field depend on the applied field? (c) bonus question: what does the resonant field going to zero at $H=4\pi M_S$ imply?

4) For a hydrogen atom in an applied field of 0.05 or 1 T.

a) What is the probability of the nuclear spin to be parallel to the applied field at each field?

b) What is the resonant frequency of the nuclear spin at each frequency?

5). Describe three different applications of superparamagnetic particles in bio-medicines. What are the advantages of magnetic particles and how are do you optimize the particle properties.

6) In MRI why do magnetic ions affect T_1 while magnetic nanoparticles affect T_2 more than T_1? What are applications where changing T_2 may be useful?

7) Assume you could make the anisotropy of Fe much higher:

a) what is the maximum energy product permanent magnet could you design?

b) what is the minimum anisotropy you would need?

8) Describe why the effective anisotropy of soft magnets decreases with the grain size diameter (D) as D^{-6}.

9) Describe different loss mechanism in the use of soft magnets and why some depend on the frequency of application and others do not.