HOMEWORK #3, DUE MARCH 3

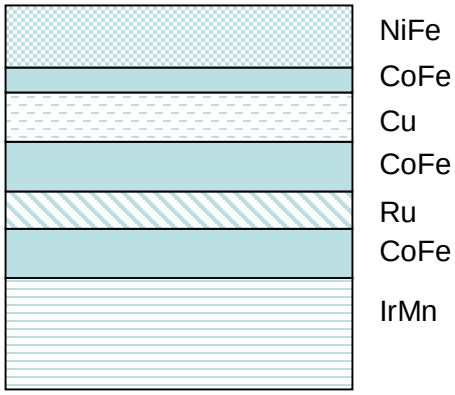
1) Assume you have a thin film with saturation magnetization M_S = 1400 emu/cm^3.
a) If the film has no magneto-crystalline anisotropy but a surface anisotropy of K_S=1 erg/cm^2, how thin would you have to make the film before the magnetization would prefer to point out of the plane?
b) If the film has a uniaxial anisotropy of Ku=4x10^6 ergs/cm^3 that points normal to the surface and a surface anisotropy of K_S=1 erg/cm^2 how thin would you have to make the films before the before the magnetization would prefer to point out of the plane?
c) What elemental magnetic materials would be reasonably described by the magnetic materials parameters in (b)?

3) If you have a film with out-of-plane first order uniaxial anisotropy described ($K_u \sin^2\theta$) that competes with the shape anisotropy you may expect the magnetization to tilt at an angle with respect to the films surface.
a) Show that this isn't true and that it will either point out-of-plane or in-plane.
b) What is the criterion that determines whether the magnetization prefers in-plane or out-of-plane?
c) Show that if the out-of-plane anisotropy includes a higher order term (that is the anisotropy is given by $K_{u1} \sin^2\theta + K_{u2} \sin^4\theta$) that a tilted ground state can be achieved for certain values of K_{u1} and K_{u2}.

4) Assume you have a film (M_S = 1000 emu/cm^3) and thickness of 5 nm. If is coupled to an antiferromagnetic layer and the loop is biased by 200 Oe:
a) what is the interfacial coupling strength (in ergs/cm^2) between the ferromagnetic and antiferromagnetic layers?
b) If you ferromagnetic layer thickness is decreased to 2 nm, what is the expected loop shift.
c) If you change the thickness of the antiferromagnetic layer, what may happen to the loop shift of the ferromagnetic layer?

5). If you have an interlayer exchange coupling between two magnetic films (J_{ex}).
a) Show that the exchange interaction acting on one of the layers appears as an effective magnetic field.
b) What is the direction of the field?
c) What is the magnitude of the field in terms of Jex and the films magnetization value and thickness?

6) A schematic of the layer structure of the GMR sensor is shown to the right which is made up of a series of magnetic and non-magnetic layers.
a) Describe the purpose of each layer
b) Describe some factors (e.g. physical phenomena) that goes into choosing the layer thicknesses (e.g. why is the Ru layer 7 Å and the Cu layer 23 Å).
c) Describe the orientation of the magnetic layers and the basic operation of the GMR head.



7) For two materials with spin polarization of 0.40 what is the expected TMR ratio between parallel and antiparallel values using an Al_2O_3 spacer layer. Why can higher TMR values be achieved using MgO tunnel barriers?