1. (15pts) Answer the following questions.

(a) Prove that the demagnetizing factor N_d of a sphere is given by $4\pi/3$ in cgs (1/3 in mks).

(b) At a field strength of H_a = 80 kA/m, the magnetic induction B of a spherical sample is 1 Tesla. Calculate the internal (or true) magnetic field H_{in} (= H_a - H_d) of this sample.

(c) How strong is the applied magnetic field H_a needed to magnetize an iron sphere to its saturation magnetization (M_s = 1.69×10^6 A/m)? Assume that the field needed to overcome the demagnetizing field H_d is much greater than the field needed to saturate the material in toroidal form.

2. (10pts) The magnetic anisotropy energy E_a for a crystal with a uniaxial anisotropy can be represented as the following,

$$E_a = K_{u0} + K_{u1}\sin^2\theta + K_{u2}\sin^4\theta + \cdots\cdots$$

Where, θ is the angle between easy axis magnetization **M**. If is the angle between <0001> direction of hexagonal Co crystal and **M**, calculate E_a in the direction perpendicular to <0001>. Where, K_{u1} = 4.1×10^5 joule/m^3, K_{u2} = 1.5×10^5 joule/m^3.

3. (15pts) Answer the following questions.

(a) For a spherical particle, calculate the critical radius below which the particle is a single-domain particle, that is, it cannot be demagnetized since it cannot support a domain wall [Hint: Balance the wall energy against the magnetostatic energy of the particle without a domain wall, $M_sH_d/2$ = $2\pi M_s^2/3$

(b) What is the critical radius for $Nd_2Fe_{14}B$ where A = 10^{-6}erg/cm, M_s = 1274 G, and K = 5 × 10^7 erg/cm^3?

4. (25pts) Answer the following questions.

(a) Explain the difference between Bloch walls and Neel walls. Which type of walls are preferred as the film thickness decreases? Explain the reason.

(b) Describe how a defect might pin or impede domain wall motion.

(c) Explain ferromagnetic-antiferromagnetic exchange coupling

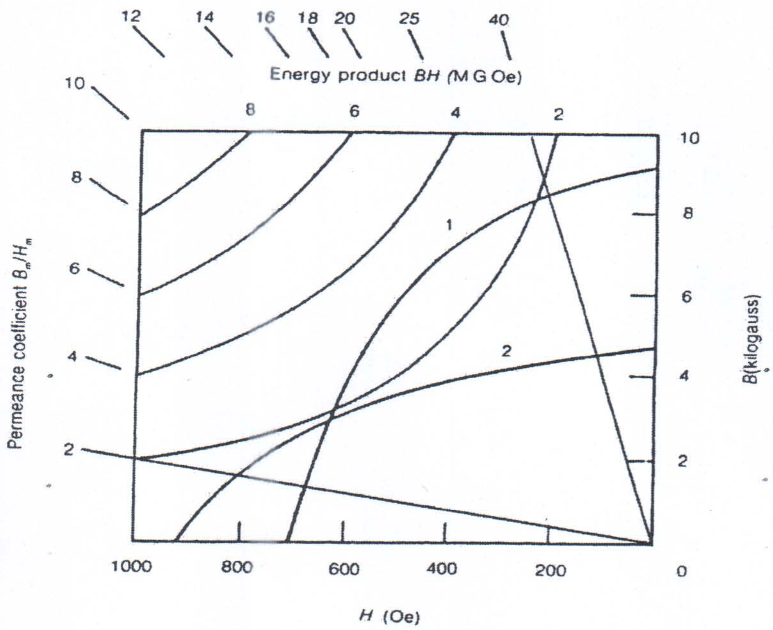
(d) Explain Feromagnetic-ferromagnetic exchange coupling

(e) What is the superparamagnetism? Explain the origin and the condition for its occurrence.

5. (15pts) Answer the questions for ferromagnets exhibiting demagnetization curves in the following figure.

(a) What are approximate values of maximum energy product for materials 1 and 2, respectively?

(b) If the material 1 is selected for the fabrication of a permanent magnet, roughly explain the demagnetization factor and also the shape to optimize its function.



(c) In order to optimize the performance for a given material, its shape should be made for its load line to pass the point of $(BH)_{max}$. Consider cylindrical samples with the same diameter. To optimize the performance of a given material with higher H_c, should the length of the sample be longer or shorter in comparison with a material of lower H_c. Explain the reason by indicating the load line and the $(BH)_{max}$ position on the demagnetization curve schematically.

6. (10pts) When the magnetic field is applied parallel or perpendicular to easy axis, the resistivity as a function of the magnetic field is dependent on the direction of the transport current. Explain the following resistivity change vs H.

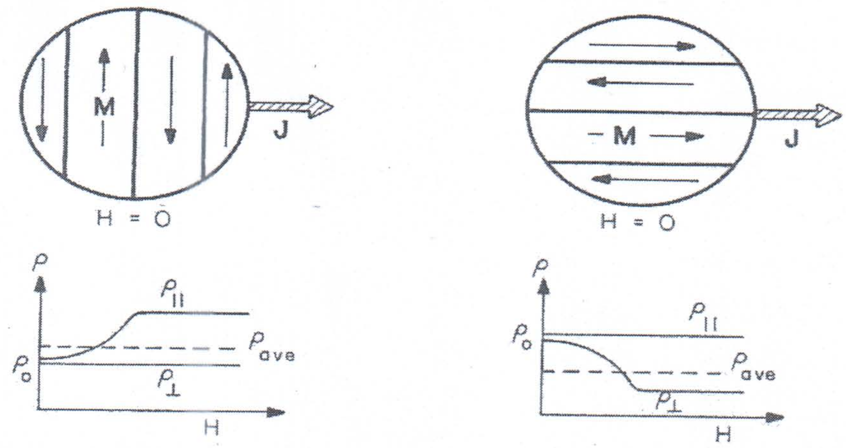


Figure 15.15 Field dependence of resistivity in fields parallel and perpendicular to J reveals the extraordinary or anisotropic magnetoresistance effect $\Delta\rho = \rho_{||} - \rho_{\perp}$ at low fields superimposed on the ordinary effects (quadratic in H) at higher fields. Note that in zero field, the resistance may be larger or smaller than ρ_{av} depending on the equilibrium domain structure. (Compare with Fig. 7.5 for magnetostriction.)

7. (10pts) Explain why magnetization curve and magnetoresistance (MR) change in the spin valve structure shown below.