

Problems Chapter 6

6.1 Show in Cartesian coordinates a) that $\alpha_1^2 + \alpha_2^2 + \alpha_3^2 = 1$ and b) that the coefficient of K_1 in Eq. 6.6 is given by 6.7.

6.2 Estimate the hard axis anisotropy energies of Fe and Ni from Eq. 6.1 and Fig. 6.1. Compare your results with those in the text.

6.3 A Ni sphere is saturated in the [100] direction. As the field is decreased the magnetization starts to rotate away from [100] below an internal field of about 230 Oe. Determine from Eqs. 6.6 and the data in Table 6.1 whether it rotates first toward the four nearest $\langle 110 \rangle$ directions or the four nearest $\langle 111 \rangle$ directions.

6.4 Work out the energy difference in Eq. 6.13. [See J. Phys. Chem. Sol. 27, 1271 (1966)] on the two dimensional cubic energy surface at $\phi = 0$.

6.5 The uniaxial energy surface in Fig. 6.6 c can be represented by Eq. 6.4. a) Write the appropriate expression for the case where the z axis is along a hard direction. b) Following Akulov's method in Section 6.4, evaluate $u_K^{\text{hard}} - u_K^{\text{easy}}$ for small angles to show that for a uniaxial magnet $K_1(T)/K_1(0) = [m(T)]^3$ at low temperature.

6.6 Write the first and second order anisotropy expressions for tetragonal symmetry analogous to Eq. 6.6. (cubic symmetry). Give the expressions in terms of the direction cosines and also express them in terms of the spherical angles θ and ϕ in order to combine similar terms.

6.7 Give a quantitative explanation of why the remanence after magnetization in the hard direction is non-zero for Fe and Ni crystals but is zero for Co (see Fig. 6.1).

6.8 Solve for and plot the field dependence of magnetization in a cubic system, $K_1 > 0$, $K_2 = 0$, for a field applied along $[110]$ and along $[111]$.

6.9 What are the conditions on the magnitude of M_s and out-of-plane crystal anisotropy for a thin film to have no in-plane magnetization?