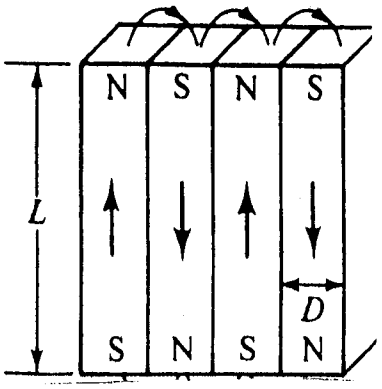
3.23 Electrical, Optical, and Magnetic Properties of Materials
Fall 2007

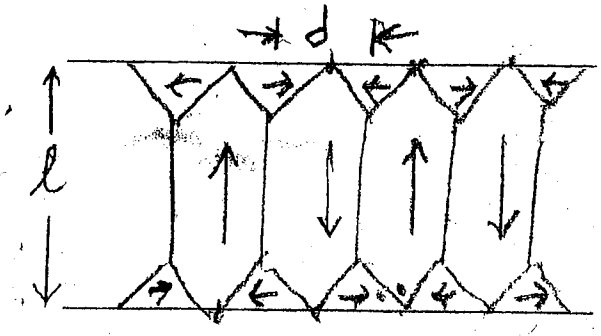
3.23 - Magnetic Materials Section - Prof. D. Paul
HOMEWORK#1 - Problems 1 thru 8, Due Tuesday, 11/20/2007

NAME_____

1. The saturation magnetization of iron is 1.7×10^6 Amperes/meter. If the density of iron is 7970 kg/m^3, calculate the magnetic moment per iron atom in amp meter^2 (=Joules/tesla) and in Bohr magnetons. (1 Bohr magneton = 9.27×10^{-24} joules/tesla. The relative atomic mass of iron = 56.)

2. Estimate the domain spacing, d, in
a) a uniaxial single crystal of cobalt material with slablike domains of length L and spacing d. Assume that the direction of magnetization of the domains lies along the easy axis.
The magnetostatic energy per unit area of the surface is given as $1.7 \times 10^{-7} M_s^2 d$. The domain wall energy for cobalt is 7.6×10^{-3} Joules/meter^2 and $M_s = 1.42 \times 10^6$ A/m. Calculate the domain spacing when the specimen thickness, (i.e.,domain length L) equals 0.01 m.
b) a cubic crystal with $K_1 > 0$ having domain structure on a surface parallel to a (100) plane as shown:



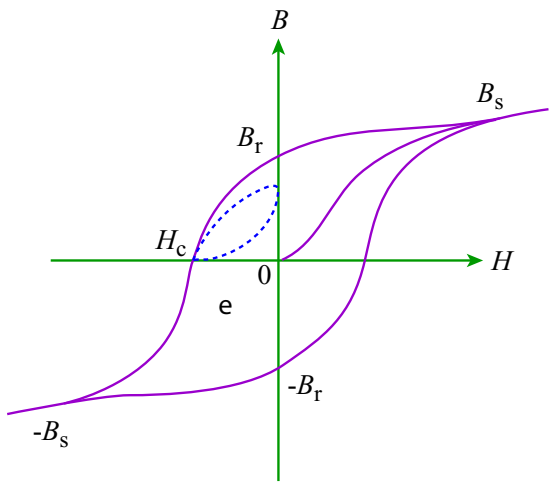


3. Sketch and explain how the domain structure of an initially unmagnetized sample of a ferromagnetic material changes during magnetization to saturation.

4. What characteristic would you expect to see in the magnetization curve and hysteresis loop of a perfect (defect free) ferromagnetic material with a large magnetocrystalline anisotropy? Suggest an application for such a material.

5. What characteristic would you expect in the magnetization curve and hysteresis loop of a ferromagnetic material which has many defects? Suggest an application for such a material.

6. Figure below shows the major hysteresis loop for our ferromagnetic material (solid line) and a minor hysteresis loop (dashed line). Describe the variation in domain pattern around the MINOR hysteresis loop.



Major (solid line) and minor (dashed line) hysteresis loops for a ferromagnetic material.

Figure by MIT OpenCourseWare.

7. Sketch the domain structure you would expect in spherical samples of ferromagnetic materials with the following properties:

a) zero magnetocrystalline anisotropy
b) large uniaxial anisotropy
c) large magnetostriction
d) a very small sample

8. What characteristics would you expect in the hysteresis loop of a ferromagnetic particle with average magnetocrystalline anisotropy, which is so small that it consists of a single domain. Suggest an application.