Homework 6.3.

1. A coaxial cable consists of two very long cylindrical tubes, separated by linear insulating material of magnetic susceptibility χ_m. A current I flows down the inner conductor and returns along the outer one; in each case the current distributes itself uniformly over the surface of each conductor.
   a. Find the magnetic H-field in the region between the tubes.
   b. Use the answer of (a) to calculate the magnetic B-field.
   c. Use the answer of (a) to calculate the magnetization of the material.
   d. Calculate from the answer of (c) the bound current densities.
   e. Now use the standard Ampere's law in terms of B to check the answer to (b).

2. A current I flows down a long straight wire of radius a. If the wire is made of copper (linear material) with susceptibility χ_m, and the current is distributed uniformly.
   (a) What is the magnetic B-field a distance s from the axis?
   (b) Find all the bound currents.
   (c) What is the net bound current flowing down the wire?

3. If J_{free}=0 everywhere, the curl of H vanishes and we can express H as the gradient of a scalar potential W, i.e.

   $$\vec{H} = -\nabla W$$

   According to equation 6.23 then:

   $$\nabla^2 W = \left(\nabla \bullet \vec{M}\right)$$

   So W obeys Poisson's equation, with $\nabla \bullet \vec{M}$ as the source. This opens up all the machinery of Chapter 3. Find the field inside a uniformly magnetized sphere (i.e. example 6.1) by separation of variables (Hint: $\nabla \bullet \vec{M} = 0$ everywhere except at the surface (r=R), so W satisfies Laplace's equation in the regions r<R and r>R; use equation 3.65, and from Eq 6.24 figure out the appropriate boundary condition on W.

4. A sphere of linear magnetic material is placed in an otherwise uniform magnetic field Bo. Find the new field inside the sphere. Use the same method as in problem 3.
   (a) Determine the B for large r.
   (b) Determine the H for large r.
   (c) Determine the W for large r.
   (d) How does W look inside the sphere and outside the sphere.
   (e) Apply the boundary conditions on W and dW/dr at the surface of the sphere. Solve for $W_{in}(r,\theta)$.
   (f) Determine H_{in} from W_{in}.
   (g) Determine B_{in} from H_{in}.