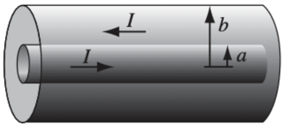
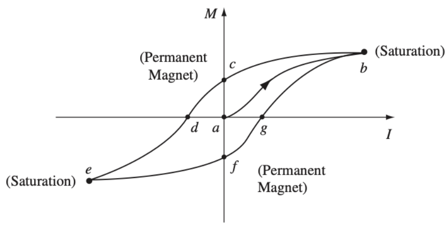
Exercise sheet #11

Problem 1. For a bar magnet (a short circular cylinder of radius a and length L with a "frozen-in" uniform magnetization M parallel to its axis), make careful sketches of $\mathbf{M}, \mathbf{B}$, and $\mathbf{H}$, assuming L is about $2a$. Compare with your results in Problem 3 from Exercise sheet 7.

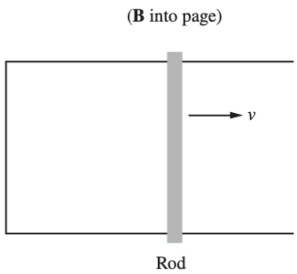
Problem 2. A coaxial cable consists of two very long cylindrical tubes, separated by linear insulating material of magnetic susceptibility χ_m. A current I flows down the inner conductor and returns along the outer one; in each case, the current distributes itself uniformly over the surface (See figure below). Find the magnetic field in the region between the tubes. As a check, calculate the magnetization and the bound currents, and confirm that (together, of course, with the free currents) they generate the correct field.



Problem 3. How would you go about demagnetizing a permanent magnet at point c in the hysteresis loop pictured below? That is, how could you restore it to its original state, with $M = 0$ at $I = 0$?



Problem 4. In the figure below a conducting rod is pulled to the right at speed v while maintaining contact with two rails. A magnetic field points into the page. From the reasoning in lecture, we know that an induced emf will cause a current to flow in the counterclockwise direction around the loop. Now, the magnetic force $q\mathbf{uB}$ is perpendicular to the velocity $\mathbf{u}$ of the moving charges, so it can't do work on them. However, the magnetic force $\mathbf{f}$ in the equation $\mathcal{E} \equiv \frac{1}{q}\int \mathbf{f} \cdot d\mathbf{s}$ certainly looks like it is doing work. What's going on here? Is the magnetic force doing work or not? If not, then what is? There is definitely something doing work because the wire will heat up.



Problem 5. A long straight stationary wire is parallel to the y axis and passes through the point $z = h$ on the z axis. A current I flows in this wire, returning by a remote conductor whose field we may neglect. Lying in the xy plane is a square loop with two of its sides, of length b, parallel to the long wire. This loop slides with constant speed v in the $\hat{\mathbf{x}}$ direction. Find the magnitude of the electromotive force induced in the loop at the moment when the center of the loop crosses the y axis. does an equal and opposite amount of negative work. So it would hardly be accurate to say that the magnetic force does work.