1. In 1897, J. J. Thomson "discovered" the electron by measuring the charge-to-mass ratio of "cathode rays" (actually, streams of electrons, with charge $q$ and mass $m$) as follows:

(a) First he passed the beam through uniform crossed electric and magnetic fields $E$ and $B$ (mutually perpendicular, and both of them perpendicular to the beam), and adjusted the electric field until he got zero deflection. What, then, was the speed of the particles (in terms of $E$ and $B$)?

(b) Then he turned off the electric field, and measured the radius of curvature, $R$, of the beam, as deflected by the magnetic field alone. In terms of $E$, $B$, and $R$, what is the charge-to-mass ratio ($q/m$) of the particles?

2. Calculate the magnetic field at point $P$ produced by the conductor of the figure, assuming that it carries a current $I$. (Notice that the two straight segments are parallel to the $x$-axis).

3. (a) Find the force on a square loop placed as shown in the left figure, near an infinite straight wire. Both the loop and the wire carry a steady current $I$.

(b) Find the force on the triangular loop shown in the right figure. Both the loop and the wire carry a steady current $I$ and the sides of the triangle are equal.

4. A current $I$ flows down a wire of radius $a$.

(a) If it is uniformly distributed over the surface, what is the surface current density $K$?

(b) If it is distributed in such a way that the volume current density is inversely proportional to the distance from the axis, what is $J(s)$?