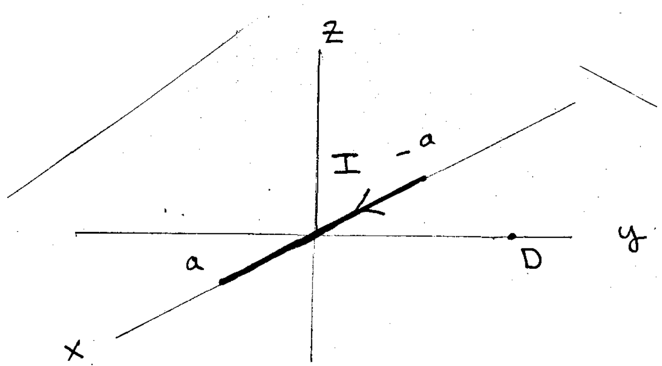
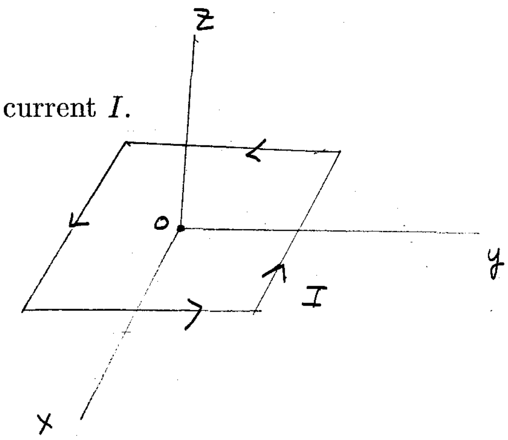
1. (a) State the Biot-Savart law for computing the magnetic field $\vec{B}(\vec{r})$, define all your terms.

(b) Consider a segment of a wire, carrying a current I, located along the $x-$axis from $x = -a$ to $x = a$. Compute the magnetic field at a point $\vec{r}$ defined by the Cartesian coordinates $(x, y, z) = (0, D, 0)$, with $D > 0$. A correct expression would take the form of a one-dimensional integral with all terms defined. Do **not** evaluate the integral.



2. Consider a square loop of wire, of side w, carrying a current I.



(a) Determine the magnetic dipole moment $\vec{m}$ of the loop.

(b) Determine the approximate magnetic field a distance $z \gg w$ above the center of the square, O.

(c) Determine the magnetic field at the center of the square, O.

3. An infinitely long circular cylinder of radius R carries a magnetization $\vec{M} = ks^2\widehat{\phi}$, where k is a constant, s is the distance from the axis and $\widehat{\phi}$ is the azimuthal unit vector.

(a) Consider the the vector potential $\mathbf{A}$ for the given situation. Is the vector potential expressed as a volume integral, a surface integral, or a sum of a volume integral and a surface integral? Explain.

(b) Determine the bound current density, $\mathbf{J_b}$.

(c) Determine the total bound current, and then define this quantity to be I_b.

(d) Determine the magnetic field $\mathbf{B}$ outside the cylinder.

(e) Determine the magnetic field $\mathbf{B}$ and $\mathbf{H}$ inside the cylinder.