5.1) A particle of charge q enters a region of uniform magnetic field $\vec{\mathbf{B}}$ (pointing *into* the page). The field deflects the particle a distance d above the original line of flight, as shown in Fig. 5.8. Is the charge positive or negative? In terms of a, d, B, and q, find the momentum of the particle.

The magnetic force is given as a cross product of the velocity of a charge and the magnetic field which it is immersed in:

$$\vec{\mathbf{F}} = q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$

We can determine the sign of the charge on q by seeing if the direction of the force is parallel or anti-parallel to the direction of $\vec{\mathbf{v}} \times \vec{\mathbf{B}}$. Using the right hand rule, we see that the force points up, implying that the charge must be positive.

Now, we know that a charge moving in a constant magnetic field with velocity perpendicular to the field undergoes circular motion:

$$\begin{cases} x = r\cos\left(\frac{qB}{m}t\right) \\ y = r\sin\left(\frac{qB}{m}t\right) - r \end{cases}$$

We can solve for the radius of motion using the point (d, a), giving

$$r = \frac{a^2 + d^2}{2d}$$

Hence, using basic facts about centripetal motion, we have

$$\begin{aligned} F = \frac{mv^2}{r} &= qvB \\ \Rightarrow p &= qBr \end{aligned}$$

giving

$$\boxed{p = \frac{qB(a^2 + d^2)}{2d}}$$

5.5) 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?

The length of the strip perpendicular to the flow of current is $2\pi a$, and since the current is uniform over the surface, then

$$\boxed{K = \frac{I}{2\pi a}}$$

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

We can write

$$J = \frac{k}{s}$$

find k in terms of the total current as follows:

$$I = \int \vec{\mathbf{J}} \cdot \mathrm{d}\vec{\mathbf{a}} = \int \frac{k}{s} s \, \mathrm{d}\phi \, \mathrm{d}s = k(2\pi)a$$
$$\Rightarrow k = \frac{I}{2\pi a}$$

Hence,

$$\boxed{J(s) = \frac{I}{2\pi a s}}$$