1) Problem 5.1

Since \( \mathbf{v} \times \mathbf{B} \) points upward, and that is also the direction of the force, \( q \) must be positive. To find \( R \), in terms of \( a \) and \( d \), use the pythagorean theorem:

\[
(R - d)^2 + a^2 = R^2 \Rightarrow R^2 - 2Rd + d^2 + a^2 = R^2 \Rightarrow R = \frac{a^2 + d^2}{2d}.
\]

The cyclotron formula then gives

\[
p = qBR = \frac{qB(a^2 + d^2)}{2d}.
\]

2) Problem 5.4

Suppose \( I \) flows counterclockwise (if not, change the sign of the answer). The force on each side is zero; the force on the top is \( IaB = Iak(a/2) = Ika^2/2 \), (pointing upward), and the force on the bottom is \( IaB = -Ika^2/2 \) (also upward). So the net force is \( \mathbf{F} = Ika^2 \hat{z} \).

3) Problem 5.5

(a) \[ K = \frac{I}{2\pi a}, \] because the length-perpendicular-to-flow is the circumference.

(b) \[ J = \frac{\alpha}{s} \Rightarrow I = \int J \, da = \alpha \int \frac{1}{s} ds \, d\phi = 2\pi \alpha \int ds = 2\pi \alpha a \Rightarrow \alpha = \frac{I}{2\pi a}; J = \frac{I}{2\pi a s}. \]

4)