I. THE EQUATIONS OF MOTION

$$m\ddot{v} = \sum_i \mathbf{F}_i$$

This gives us:

$$\Rightarrow m \begin{bmatrix} \ddot{\mathbf{x}} \\ \ddot{\mathbf{y}} \\ \ddot{z} \end{bmatrix} = \sum_i \begin{bmatrix} \mathbf{F}_x \\ \mathbf{F}_y \\ F_z \end{bmatrix} = \sum_i$$

$$m\ddot{x} = \sum_i F_{x,i}$$

Simple particle:

$$\Rightarrow \begin{bmatrix} \dot{x} \\ \dot{y} \\ 0 \end{bmatrix} \times \begin{bmatrix} 0 \\ 0 \\ B_0 \end{bmatrix} = \begin{bmatrix} B_0\dot{y} \\ B_0\dot{x} \\ 0 \end{bmatrix}$$

$$\begin{aligned} m\ddot{x} &= F_x \\ &= qE_x + (q\mathbf{V} \times B)_x \\ &= -q\frac{\partial v}{\partial x} + q \begin{bmatrix} \dot{x} \\ \dot{y} \\ 0 \end{bmatrix} \times \begin{bmatrix} 0 \\ 0 \\ B_0 \end{bmatrix} \quad = -q\left(-\frac{V_0}{d^2}x\right) + qB_0\ddot{y} \end{aligned}$$

$$\ddot{x} - \frac{qB_0}{m}\dot{y} - \frac{qV_0}{md^2}x = 0$$

$$\Rightarrow \ddot{x} - \omega_0\dot{y} - \frac{1}{2}\omega_z^2 x = 0$$

$$\begin{aligned} m\ddot{y} &= F_y \\ &= qE_y + (q\mathbf{V} \times B)_y \\ &= -q\frac{\partial v}{\partial y} - qB_o\dot{x} \end{aligned}$$

$$\Rightarrow \ddot{y} + \frac{qB_0}{m}\dot{x} - \frac{qV_0}{md^2} = 0$$

$$m\ddot{z}$$