$$
\begin{aligned}
m\dot{v}_x &= e[v_y B_z(y)] \\
m\dot{v}_y &= e[-v_x B_z(y) + E]
\end{aligned}
$$

$$
\begin{aligned}
B_z(y) &= B_0 + \beta y \\
\dot{v}_x &= 0
\end{aligned}
$$

$$
\begin{aligned}
\dot{v}_y &= \frac{e}{m}[-v_x(B_0 + \beta y) + E] \\
v_x &= \sqrt{(v + \mathrm{d}v)^2 \cos\left(\frac{\mathrm{d}\theta}{2}\right)^2 - \frac{eBv d_{\mathrm{tot}} d_{\mathrm{w1}} \sin\left(\frac{\mathrm{d}\theta}{2}\right)}{2m d_{\mathrm{w}}}} \\
&\approx v + \mathrm{d}v - \frac{e}{m}\frac{B}{8}\frac{d_{\mathrm{tot}} d_{\mathrm{w1}}}{d_{\mathrm{w}}}\mathrm{d}\theta \\
\alpha &= \frac{e}{m}\frac{B}{8}\frac{d_{\mathrm{tot}} d_{\mathrm{w1}}}{d_{\mathrm{w}}} \\
v_x &= v + \mathrm{d}v - \alpha\mathrm{d}\theta \\
\dot{v}_y &= \frac{e}{m}[-(v + (\mathrm{d}v - \alpha\mathrm{d}\theta))(B_0 + \beta y) + E] \\
\dot{v}_y &= \frac{e}{m}[-(\cancel{vB_0} + (\mathrm{d}v - \alpha\mathrm{d}\theta)B_0 + v\beta y + \cancel{(\mathrm{d}v - \alpha\mathrm{d}\theta)\beta y}) + \cancel{E}] \\
\dot{v}_y &= -\frac{e}{m}[(\mathrm{d}v - \alpha\mathrm{d}\theta)B_0 + v\beta y]
\end{aligned}
$$

$$
\begin{aligned}
y"[t] &= -\frac{e}{m}\left(v\beta y[t] + (\mathrm{d}v - \alpha\mathrm{d}\theta)B\right) \\
y'[0] &= (v + \mathrm{d}v)\sin\frac{\mathrm{d}\theta}{2} \\
y[0] &= d_{\mathrm{w1}}\sin\frac{\mathrm{d}\theta}{2} + \frac{m\mathrm{d}v}{eB} \\
x"[t] &= 0 \\
x[0] &= 0 \\
x'[0] &= v_{\mathrm{xwf}}
\end{aligned}
$$