Example: Particle Motion - Electrostatic Analyzer

Two oppositely charged, curved metal plates establish an electric field given by $E = E_0 \frac{b}{r}$ where E_0 and b are constants representing the electric field and length respectively. The field points toward the center of curvature, and r is the distance from the center.

Find an expression for the speed v with which a proton entering vertically from below will leave the device moving horizontally.

Here, we want uniform circular motion so equation 8 is written with the given field and $a = \dfrac{v^2}{r}$.

$$a = \frac{v^2}{r} = \frac{eE}{m} = \frac{eE_0 b}{mr}$$

Solving for v gives:

$$v^2 = \frac{eE_0 b}{m} \qquad v = \sqrt{\frac{eE_0 b}{m}}$$