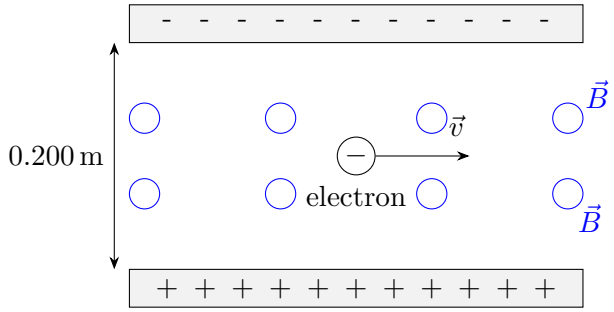
Physics 112: General Physics II: Electricity, Magnetism, and Optics
Velocity Selector

Problem 1: (10 pts.) An electron with speed $4.00 \times 10^4\,\text{m/s}$ passes from left to right between two parallel plates spaced 0.200 m apart. The plates are charged as shown such that the electric potential difference ΔV between them is 200.0 V. There is also a uniform magnetic field $\vec{B}$ perpendicular to the page. What magnetic field would be required to make the electron pass straight through without deflection? Give both the magnitude and the direction.



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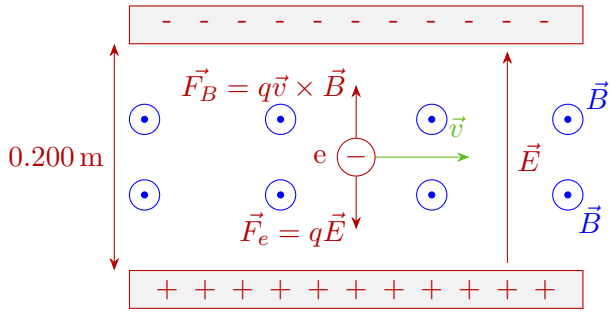

The electric field points upward (from positive to negative charges). The electric force is then downwards (since the electron is negatively charged). In order for the net force to be zero, the magnetic force must point upwards. If the magnetic field points out of the page, then $\vec{v} \times \vec{B}$ points down. Since the electron is negatively charged, $q\vec{v} \times \vec{B}$ then points upward.

Since the velocity and magnetic field are perpendicular, the cross product magnitude is simply $F_B = qvB$. Also, note that the electric field magnitude is $\frac{\Delta V}{d}$.

$$
\begin{aligned}
F_B &= F_e \\
qvB &= qE \\
B &= \frac{E}{v} = \frac{\Delta V/d}{v} \\
B &= \frac{200.0\,\text{V}/0.200\,\text{m}}{4.00 \times 10^4\,\text{m/s}} = \frac{1000\,\text{V/m}}{4.00 \times 10^4\,\text{m/s}} = \boxed{0.0250\,\text{T}}
\end{aligned}
$$