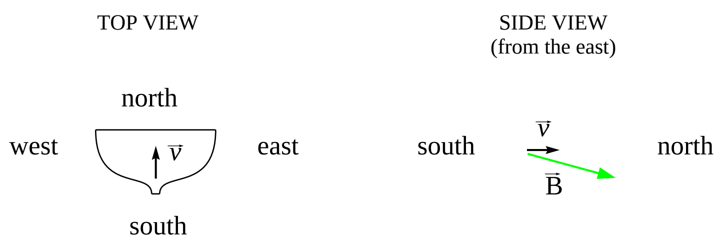
Television



(a.) The magnetic force is $\vec{F} = q\vec{v} \times \vec{B}$. By the right-hand rule, $\vec{v} \times \vec{B}$ points to the west, but q is negative so the force points to the east. The beam deflects to the right.

(b.) First find the magnitude v:

$$\begin{aligned} \text{KE} &= 12.0 \text{ keV} = \left(12.0 \times 10^3 \text{ eV}\right)\left(1.60 \times 10^{-19} \text{ J/eV}\right) = 19.2 \times 10^{-16} \text{ J} \\ \text{KE} &= \tfrac{1}{2} m_e v^2 \quad \Longrightarrow \quad v = \sqrt{2\text{KE}/m_e} = 6.49 \times 10^7 \text{ m/s} \end{aligned}$$

This is a substantial velocity. . . 20% the speed of light. (High accuracy television design must use relativistic mechanics. For this problem, it's sufficient to use the Newtonian approximation.)

Then find the force: Because the component of $\vec{B}$ parallel to $\vec{v}$ does not contribute to the magnetic force, the magnitude of the force is $F = qvB_d$, where B_d is the component of $\vec{B}$ that points downward. Thus

$$a = \frac{qvB_d}{m_e} = \frac{(1.60 \times 10^{-19} \text{ C})(6.49 \times 10^7 \text{ m/s})(55.0 \times 10^{-6} \text{ T})}{9.11 \times 10^{-31} \text{ kg}} = 6.27 \times 10^{14} \text{ m/s}^2.$$

(c.) With a velocity so large the deflecting force acts briefly, so the deflection will be tiny. We may safely disregard the circular character of the trajectory (with force changing direction to be always perpendicular to $\vec{v}$) and regard the force as a constant directed to the east. In other words, this becomes a familiar constant acceleration problem, like a $g = 9.8$ m/s^2 problem!

To travel 20.0 cm at $v = 6.49 \times 10^7$ m/s requires time 3.09×10^{-9} s.

During that time the deflection is

$$x = \tfrac{1}{2} a t^2 = 3.00 \text{ mm}.$$

Grading: Starting out — for example a sketch: 2 points

part (a): 2 points

part (b), find velocity: 2 points

part (b), find acceleration: 2 points

part (c): 2 points