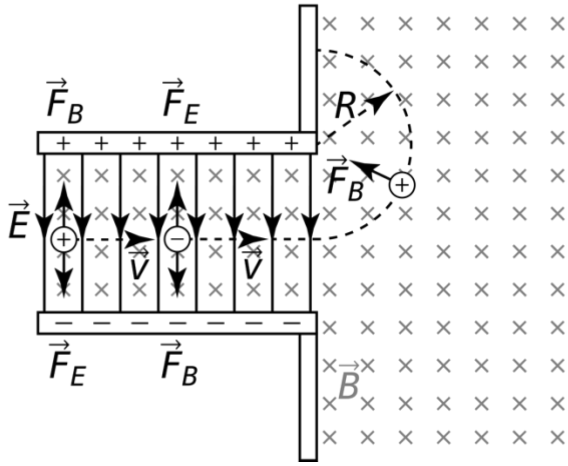
Flipping Physics Lecture Notes:
Mass Spectrometer
http://www.flippingphysics.com/mass-spectrometer.html

Because it involves many concepts that are likely to come up on the AP exam, let's take a moment to analyze a mass spectrometer:

The magnetic field is uniform into the page throughout, and in the velocity selector, the electric field uniform and down.



Velocity Selector:

- For a positive charge the magnetic force is up and the Coulomb force is down.
- For a negative charge the magnetic force is down and the Coulomb force is up.
- Regardless of whether the charge is positive or negative, the free body diagrams result in the same Newton's Second Law equation:

$$\sum F_y = F_B - F_E = ma_y = 0 \Rightarrow F_B = F_E$$

$$\Rightarrow qvB\sin\theta = qE \Rightarrow vB\sin(90°) = E \Rightarrow v = \frac{E}{B}$$

- So, all charged objects with the same constant velocity will all move in a straight horizontal line in the velocity selector. Regardless of mass, charge sign, and charge magnitude.

Deflection Chamber:

- The uniform magnetic field is the only field present in the deflection chamber.
- The only force acting on the charged particle is the magnetic force which acts inward.
    - The charged particles will move along a circular path with radius, R.
    - Positive charges will be deflected upward.
    - Negative charges will be deflected downward.
- Again, we use Newton's Second Law:

$$\sum F_{\text{in}} = F_B = ma_c \Rightarrow qvB\sin\theta = qvB\sin(90°) = qvB = m\left(\frac{v_t^2}{R}\right)$$

$$\Rightarrow qB = \frac{mv_t}{R} \Rightarrow qB = \frac{m\left(\frac{E}{B}\right)}{R} \Rightarrow mE = qRB^2 \Rightarrow \frac{m}{q} = \frac{RB^2}{E}$$

The mass spectrometer is a tool for determining velocities and mass-to-charge ratios of electric charges. Imagine how useful this could be for learning information about new particles!