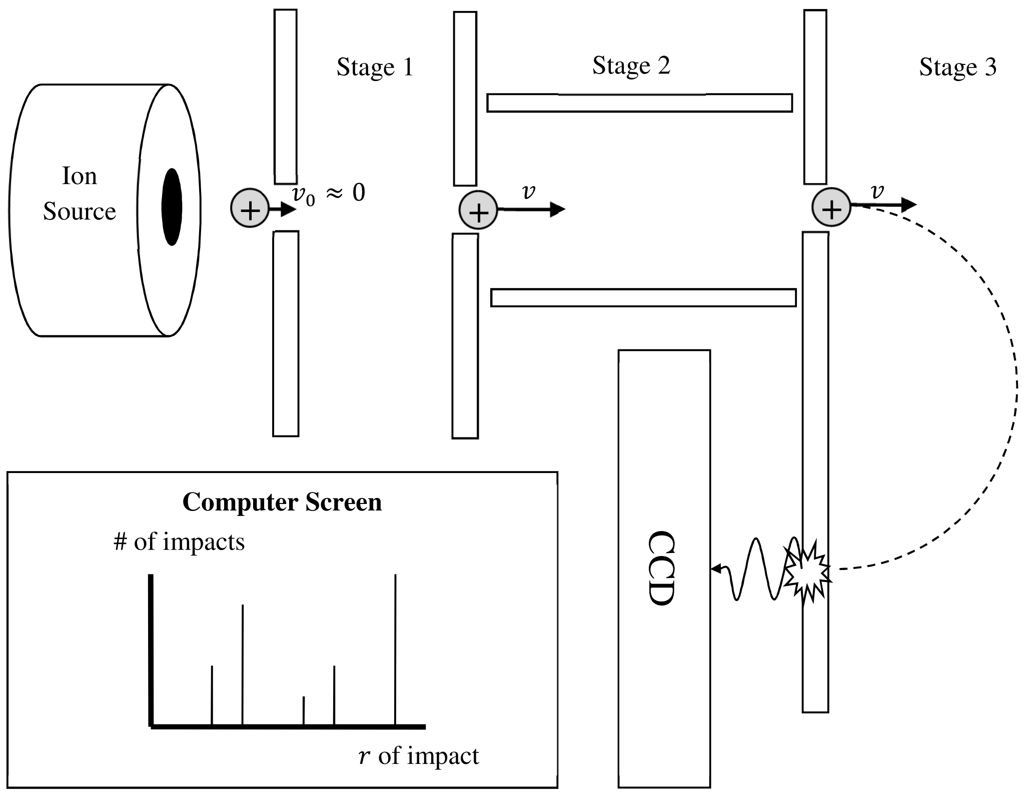

28.6 The above figure shows a crude version of a mass spectrometer. Suppose the ion source produces positive ions with positive charge q & mass m moving very slowly ($v_0 \approx 0$).

In Stage 1 the positive ions enter a region with electric field only. The external electric field will accelerate the ions the right. In Stage 1 the plate potential difference is ΔV_1 with plate spacing d_1.

In Stage 2 a *different* external electric field is present as well as an external magnetic field. In Stage 2 the plate potential difference is ΔV_2 with plate spacing d_2. The magnetic field points the same direction as in Stage 3.

In Stage 3 a different external magnetic field is present (magnitude B_3). In Stage 3 no electric field is present. In Stage 3 the ion moves with speed v.

a) In what direction is the external magnetic field oriented? Hint: consider Stage 3. Note: assume the field is aligned with one of the principle axes to minimize the required field strength.
b) What direction is the magnetic force on the ion in Stage 2?
c) For the ion to pass undeflected through Stage 2, which plate must be at higher electric potential?
d) For the ion to be accelerated to the right in stage 1, which plate must be at higher potential?
e) Determine the potential difference require for the accelerator in Stage 1. Assume $v_0 \approx 0$.
f) Determine the external magnetic field magnitude required in Stage 2.
g) Determine the radius of curvature of the ion in Stage 3.
h) What happens to the radius of curvature if *charge* increases by a factor of 2?
i) What happens to the radius of curvature if *mass* increases by a factor of 2?
j) What happens to the radius of curvature if *charge* & *mass* both increase by a factor of 2?
k) Suppose we wanted to analyze a negative ion instead. The screen remains in the same location. What would we need to do (if anything) to the orientation of the magnetic fields and the polarity of the plates?

Stage 1 is called an accelerator. Stage 2 is called a velocity selector (or region of crossed fields). Stage 3 is called an analyzer. In practice, a small number of ions have just the right velocity to pass through the selector undeflected. Different ions have different charge-to-mass ratios. Therefore, the computer screen displays a different number of impacts (# of counts) for each radius. Different materials end up with its own unique patterns (spectra).