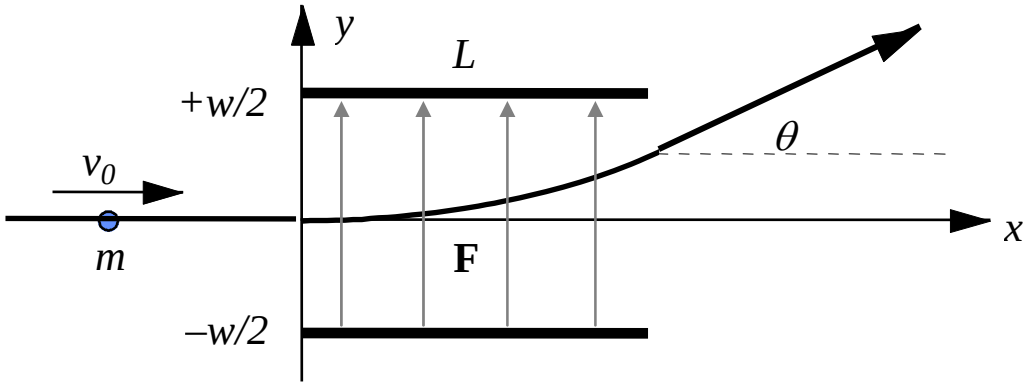
Discussion Question 1A
P212, Week 1
P211 Review: 2-D Motion with Uniform Force

The mathematics and physics of the problem below are similar to problems you will encounter in P212, where the force is due to the action of an electric field on a charged particle.

A point particle of mass m travels freely in the x-direction with uniform velocity v_0. At $x = 0$, it enters a region between two plates oriented perpendicular to the y-axis; the plate spacing is w, and then plate length in the x-direction is L. The particle enters on the mid-plane $y = 0$. While between the plates, it experiences a constant, spatially uniform force F in the $+y$-direction. After exiting the plates the particle again moves freely.



(a) Our first task will be to obtain an expression for the ***y*-coordinate** of the point at which the particle **exits** the plates. We will assume that the plate spacing is wide enough that the particle never strikes either plate. But before we start, consider these possible solutions:

(1) $y = \dfrac{F}{m(v_0 + L)}$ (2) $y = \dfrac{FL}{mv_0}$ (3) $y = \dfrac{Fw^2}{mv_0^2}$

Could any of them be correct? Why or why not? Remember, **units** and **limiting behavior** ! In fact, from *only* those two considerations, you can write down the correct answer to within a factor of 2 without using any formulas at all. Want to give it a try? (This procedure is called *dimensional analysis* and physicists use it all the time, especially when developing new theories.)

(b) Now go ahead and calculate the correct expression for y.

(c) Next, find an expression for the **maximum value** of the force F for which the particle passes through the force region without striking either plate.

(d) For the conditions of part (c), find an expression for $\tan\theta$ where θ is the **angle of deflection** at which the particle exits the force region. (Did you draw a sketch? Did you check your units?)