Physics 1135 Homework # 4: 2-d Kinematics with constant acceleration

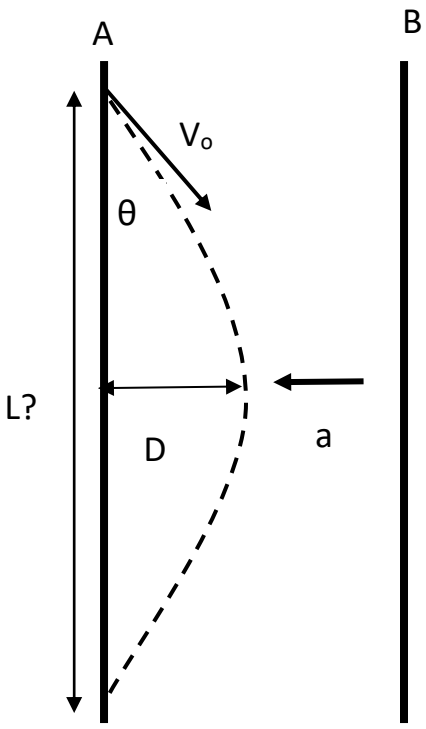
Recipe for Kinematics Problems:

- Draw a complete diagram. Every symbol you use in your calculation must be defined in the diagram.
- Begin with a starting equation from the equation sheet.
- Work in symbols and derive symbolic expressions before using numerical values.

1. A cannon is fired from a castle wall at some unknown height above the ground. The cannonball leaves the cannon with speed 30.0m/s at angle 30° above the horizontal and hits the level ground at a horizontal distance 100m from the wall.

a) Calculate the time it takes the cannon ball to hit the ground.
b) Calculate the height of the castle wall.
c) What are the *x*- and *y*-components of the cannon ball's velocity at the highest point of its trajectory?
d) What are the *x*- and *y*-components of the cannon ball's velocity just before it hits the ground?
e) Sketch, qualitatively, *x*-*t*, *y*-*t*, v_x-*t* and v_y-*t* graphs for the cannon ball's motion.

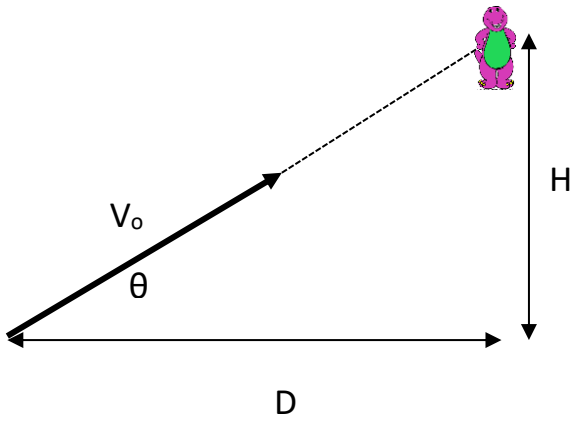
2. An electron is moving between two plates, A and B. It starts at plate A with an initial velocity of magnitude V_0 that is directed at an angle θ with respect to the plate, as shown in the figure. It is under the influence of a constant acceleration of magnitude *a* that is directed to the left.
The figure shows a view from above. You may disregard gravity which is directed into the page, perpendicular to your paper.



a) Derive an expression, in terms of system parameters, for the maximum distance *D* to the right of plate A the electron reaches.

b) Derive an expression, in terms of system parameters, for the distance *L*, measured parallel to the plates, the electron travels before it returns to plate A.

3. In a lecture demonstration, the instructor aims a blow gun directly at Barney, a stuffed purple dinosaur, who is suspended from the ceiling at a vertical height *H* above the muzzle of the blow gun, a horizontal distance *D* away. At the instant she launches a dart with speed v_0 and angle θ above the horizontal, Barney is released from rest.



a) Derive an expression, in terms of *D*, v_0 and θ, for the time *T* it takes the dart to cover the horizontal distance *D*.

b) Derive an expression, in terms of system parameters, for the **dart's vertical position** y_D when the dart has covered the horizontal distance *D*. Use the expression for *T* you found in a).

c) Derive an expression, in terms of system parameters, for **Barney's vertical position** y_B at the instant the dart has the covered horizontal distance *D*. Use the expression for *T* you found in a).

d) Compare y_B and y_D. (Hint: aiming the blow gun directly at Barney means that *D*, *H* and θ are related!)

4. A package is dropped from an airplane flying horizontally with constant speed *V* in the positive *x*-direction. The package is released at time $t = 0$ from a height *H* above the origin. In addition to the ***vertical component*** of acceleration due to gravity, a strong wind blowing from the right gives the package a ***horizontal component*** of acceleration of magnitude ¼***g*** to the left.

Derive an expression for the horizontal distance *D* from the origin where the package hits the ground.