PhET sim problem for ball being shot up in the air.

1. In your textbook (section 2.4), Taylor solves for the case of a baseball being dropped from a high tower subject to quadratic air resistance, $F_D = -cv^2\hat{v}$. Let's look at the case of a ball being shot *up* at an initial speed v_0.

   (a) Draw a free body dagram for a ball moving vertically upwards, subject to quadratic air drag. Write down a differential equation for this situation and solve this differential equation for $v(t)$. Make a rough sketch of $v(t)$ vs. t, and briefly discuss any key features.

   (b) Using your result from the previous part, find an expression for the time it takes to reach the top of the trajectory. (It will look simpler if you write it in terms of terminal velocity, which satisfies $v_t^2 = mg/c$.)

   (c) Now download the PhET simulation at: `http://phet.colorado.edu/en/simulation/projectile-motion`. On the top right, switch the object to baseball. This sim uses quadratic drag: $F_D = -\frac{1}{2}c_0 A\rho_{air}v^2\hat{v}$, where c_0 is the drag coefficient, A is the cross-sectional area of the object being shot, and ρ_{air} is the denstiy of air $= 1.3 \quad kg/m^3$. (The sim shows you the value of c_0 and diameter it has picked for a baseball, on the right side of the sim). Use your formula in part b for "time to top" with these numbers to deduce what numerical initial velocity v_0 you need to get the ball to reach the top of its trajectory at precisely $t = 3$ sec. Now test it!. You can input v_0 into the sim and fire the cannon at $90°$ (or $88 - 89°$ if it is easier to see the trajectory) and switch on air resistance. The little + and - glasses let you zoom in or out. Does the ball reach the top at $t = 3$ sec? (It should!)

   (d) When you fired the ball on teh PhET sim, did it take longer for the ball to go from the ground to the top of the trajectory or from the top of the trajectory to the ground? Explain why this is the case.

   (e) Now let's look at another interesting feature of shooting an object up in the air. Start by increasing the value of v_0 in the sim. Double it from what you had before, then increase it by 10, and then by 100. What is happening to the time to reach the top? Use your formal mathematical results to explain what is happening!

   (f) Play with the PhET sim a little more and explore anything you are interested in. Write down one question that you have about something you notice when playing with the sim.