Activity 2: Quadratic Drag Force

1. Consider a body moving horizontally (like a railcar on a track) subject to a quadratic drag force:

$$\vec{F}_d = -cv^2\hat{v}$$

   (a) Write Newton's second law $\vec{F} = m\vec{a}$ in the x-direction:

   (b) Write the answer to part (a) as a differential equation for v_x

   (c) Solve for $v_x(t)$

2. Now consider a ball that starts from rest, then falls only vertically through the air. The ball is subject to both gravity and a quadratic drag force:

$$\vec{F}_d = -cv^2\hat{v} \qquad \vec{F}_g = -mg\hat{y}$$

   (a) Write Newton's second law $\vec{F} = m\vec{a}$ in the y-direction:

   (b) Find the terminal velocity

   (c) Write the answer to part (a) as a differential equation for v_y

   (d) Solve for $v_y(t)$

3. Now consider a projectile moving through the air along a path that's both vertical and horizontal. Write Newton's second law in both directions:

   (a) Write $\vec{F}_d$ in terms of $\hat{x}$ and $\hat{y}$. (Hint: rewrite this to get a factor of $\vec{v}$, and then use $\vec{v} = v_x\hat{x} + v_y\hat{y}$)

   (b) $m\dot{v}_x =$

   (c) $m\dot{v}_y =$

   (d) Based on the above, why are the equations of motion for quadratic air resistance more difficult to solve than for linear air resistance?