Warm Up: Kinematics in 2D and 3D

Prof. Jordan C. Hanson

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1 Memory

1. $y(t) = -\frac{1}{2}gt^2 + v_{i,y}t + y_i$ ... Accelerating system vertically.
2. $x(t) = v_{i,x}t + x_i$ ... Constant velocity horizontally.
3. $v_f^2 = v_i^2 + 2a(x_f - x_i)$ ... Kinematic equation without time.

2 Kinematics in 2D and 3D

1. Imagine a system propagating through 3D space with a velocity vector $\vec{v} = (2t^2 - t)\hat{i} + 2t\hat{j}$. (a) Write the acceleration vector by taking the derivative. (b) What is $\vec{a}(0.5)$?

2. Suppose a system is thrown into the air, accelerating downwards due to gravity, but proceeding horizontally at constant velocity.
   - We have shown in a previous calculation that the trajectory follows $y(x) = -ax^2 + b$, with $b = \tan\theta$ and $a = \frac{1}{2}g/v_{i,x}^2$.
   - Note in Fig. 1 that breaks the initial velocity v_i into two components:

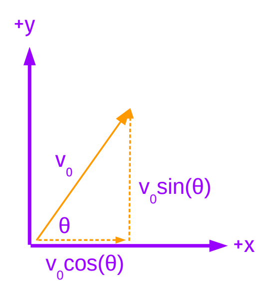

Figure 1:

   - Convince yourself that the x-component of the initial velocity is $v_{i,x} = v_i \cos\theta$, and $v_{i,y} = v_i \sin\theta$ by performing Pythagorean theorem to get the hypoteneuse.
   - Suppose a system is launched at a 60 degree angle with speed $v_i = 20$ m/s from the origin. (a) Where will it land? (b) How fast is it going when it lands?