AP Physics - 2D Motion - Projectiles

Note Title 9/9/2007

TODAY'S EXAMPLE: How far will the projectile launcher shoot if fired horizontally from a height of 1.47 m?

Rule #1 of 2D projectile motion:
What happens in the horizontal direction does not affect what happens in the vertical direction.

Example: If a bullet is shot horizontally out of a pistol, and another bullet is dropped vertically from the same height - they will hit at the same time!

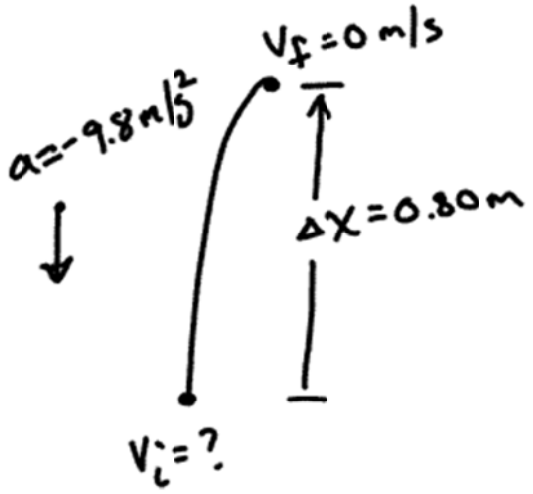
Why?
Because regardless of their very different horizontal velocities, they are both starting with zero initial vertical velocity, and are accelerating vertically due to gravity at $9.8\ m/s^2$ down.

If they are both dropping from the same height, they will both hit the ground at the same time.

Back to today's example:

We now recognize that the bullet will fall just as if it had been dropped, which we can use to figure out the time of falling, but in order to figure out how far it goes, we still need to know how fast it is moving horizontally.

Determining how fast: Shoot straight up and use equations from kinematics:



G: $v_f = 0$ m/s
$a = -9.8$ m/s^2
$\Delta x = +0.80$ m

U: v_i

E: $v_f^2 = v_i^2 + 2a\Delta x$

$v_i^2 = v_f^2 - 2a\Delta x$

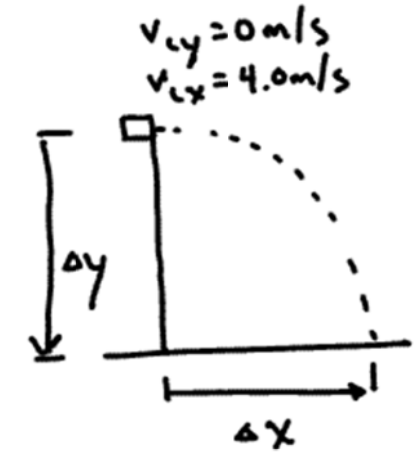
$v_i = \sqrt{v_f^2 - 2a\Delta x}$

$\rightarrow v_i = \sqrt{0^2 - 2(-9.8)(0.8)}$

$v_i = 4.0$ m/s

$\therefore$ The launcher shoots at 4.0 m/s, no matter what direction it is pointed.

Final Solution: So if the launcher shoots a projectile at 4.0 m/s horizontally from a height of 1.47m, how far will it go?



X	Y
G: $v_{ix} = v_{fx} = \bar{v}_x = 4.0\,m/s$ (because there is no acceleration in x-direction)	G: $v_{iy} = 0\,m/s$, $\Delta y = -1.47\,m$, $a_y = -9.8\,m/s^2$
	U: t
	E: $\Delta y = v_{iy}t + \frac{1}{2}a_y t^2$ ($v_{iy} = 0$)
	$\Delta y = \frac{1}{2}a_y t^2$
	$t = \sqrt{\frac{2\Delta y}{a_y}}$
	$t = \sqrt{\frac{2(-1.47)}{-9.8}}$
$t = 0.547\,s$	$t_{fall} = 0.547\,s$
U: Δx	
E: $\bar{v} = \frac{\Delta x}{\Delta t}$	
$\Delta x = \bar{v}\,\Delta t$	
$\Delta x = (4.0)(0.547)$	
$\Delta x = 2.19\,m$	

∴ The projectile should land 2.19m in front of the launcher.