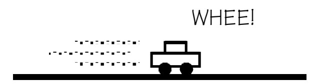
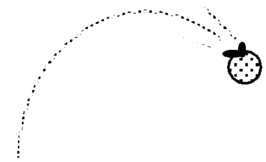
PhyzGuide: Projectiles
motion in 2 dimensions

Now that we are masters of one-dimensional kinematics, it is time to move into the world of two dimensions. With 2-D kinematics, we can study **projectile motion.**

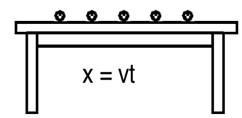


Whereas in 1-D we could only study particles confined to moving in a straight line, we can now study objects that move along in an arc: baseballs, snowballs, tomatoes, eggs, spitwads, etc.

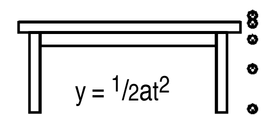


At first this may seem like an intimidating task: How can one keep track of such a complicated motion? The answer is a good news/bad news combination. The good news is that 2-D kinematics is incredibly simple: you don't need to learn *any* new equations. The bad news is that you may refuse to accept the good news above and insist on making 2-D kinematics more difficult than it is.

Here's the deal: Suppose a marble rolls horizontally along a table. It will continue to roll along at a constant speed (neglecting friction, as always). We already know how to describe *that* motion. It's a simple 1-D kinematics problem. The distance traveled by the marble is $x = vt$.

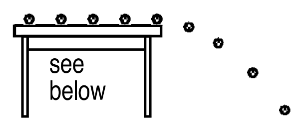


Suppose you were to drop the marble from the edge of the table. It would, of course, accelerate due to gravity. We already know how to deal with *this* 1-D motion as well. The distance traveled by the marble is $y = {}^{1}/{2}at^2$.



Now suppose you roll a marble so that it rolls at a constant horizontal velocity and then rolls off the edge of the table. It becomes a projectile. It undergoes motions in two directions at once.

In the x-direction, the marble continues at its original v_x. Remember: there is nothing in the universe acting to accelerate the marble in the *x*-direction. The equation for motion in the *x*-direction remains $x = v_xt$.



In the *y*-direction, the marble is accelerating as if it had been dropped from rest. The equation for motion in the *y*-direction is $y = {}^{1}/{2}at^2$.

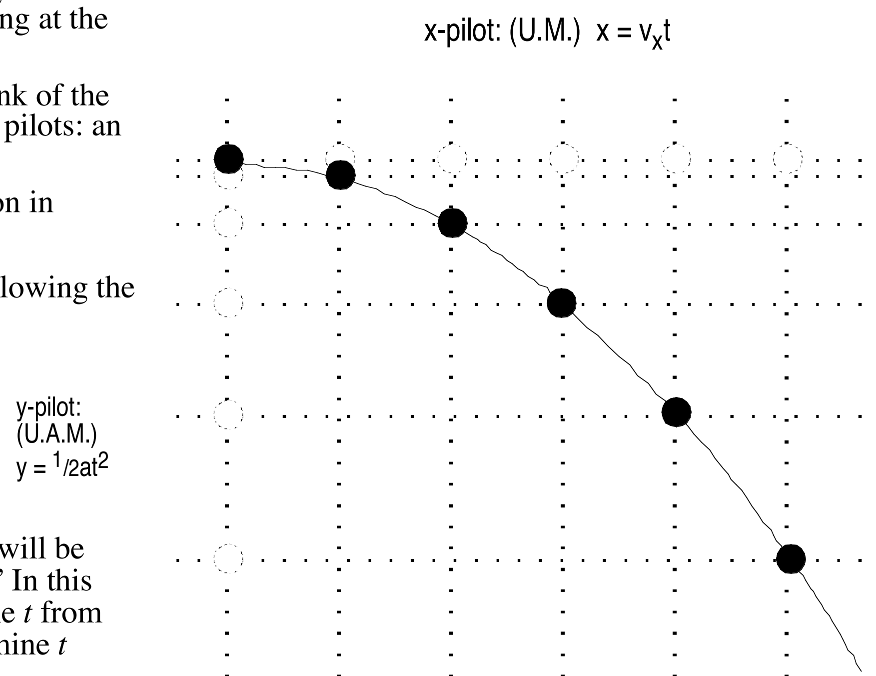
A 2-D kinematics puzzle, then, is nothing more than two 1-D kinematics puzzles happening at the same time.

The trick to solving such puzzles is to think of the projectile as a "flying machine" with two pilots: an *x*-pilot, and a *y*-pilot.

The *x*-pilot is programmed only for motion in accordance with $x = v_xt$.

The *y*-pilot is programmed for motion following the general equation $y = v_{yo}t + {}^{1}/{2}at^2$.

Suppose you were asked, "How much time will pass between the point when the marble leaves the edge of the table and when it hits the floor?"



To solve this, ask yourself, "Which pilot will be the first to know when the motion stops?" In this case, it is the *y*-pilot, so you can determine *t* from the *y*-pilot's equation. You can *not* determine *t* from the *x*-pilot's equation.