TRAJECTORY PROBLEMS

These problems assume the following:

- Motion in a horizontal direction is at constant velocity
- Motion in a vertical direction undergoes constant acceleration (usually acceleration of gravity)

The equations are therefore:

Horizontal	**Vertical**
$a_x = 0$	$a_y = -g = \text{constant}$
$v_{0x} = \text{constant}$	$v_y = v_{0y} - gt$
$x = x_0 + v_{0x}t$	$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$
	$v_y{}^2 = v_{0y}^2 - 2g(y - y_0)$

Notice, of course, that I have explicitly chosen a positive up sign convention, and have assumed g to be the magnitude of the acceleration of gravity—on the earth's surface, 9.8 m/s^2. These are of course the same equations we used in Chapter 2 for one-dimensional motion. The initial velocity is $\vec{v}_0$, so that v_{0x} and v_{0y} are the horizontal and vertical components respectively of the initial velocity.

Often it is convenient to give the initial velocity $\vec{v}_0$ in terms of a magnitude and an angle with the horizontal. In that case, as we have seen

$$v_{0x} = v_0 \cos\theta \text{ and } v_{0y} = v_0 \sin\theta ,$$

and the above equations become

Horizontal	**Vertical**
$a_x = 0$	$a_y = -g = \text{constant}$
$v_{0x} = v_0 \cos\theta = \text{constant}$	$v_y = v_0 \sin\theta - gt$
$x = x_0 + \left(v_0 \cos\theta\right)t$	$y = y_0 + \left(v_0 \sin\theta\right)t - \frac{1}{2}gt^2$
	$v_y{}^2 = \left(v_0 \sin\theta\right)^2 - 2g(y - y_0)$

At this point, we have a problem-solving scheme that we can use for *any* trajectory problem. Here's how I do it:

1. Make a careful sketch, so that I have a clear visual picture of the problem.
2. Write down the above equations.
3. Ask what I know, and what I don't know, in those equations, and look for a way to find the latter from the former.