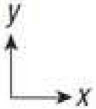
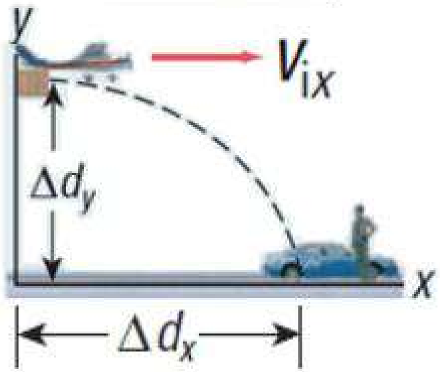
Table 1 The Five Key Equations for Uniformly Accelerated Motion

	Equation	Variables found in equation	Variable not in equation
Equation 1	$\Delta\vec{d} = \left(\frac{\vec{v}_f + \vec{v}_i}{2}\right)\Delta t$	$\Delta\vec{d}$, Δt, $\vec{v}_f$, $\vec{v}_i$	$\vec{a}$
Equation 2	$\vec{v}_f = \vec{v}_i + \vec{a}\Delta t$	$\vec{v}_f$, $\vec{v}_i$, $\vec{a}$, Δt	$\Delta\vec{d}$
Equation 3	$\Delta\vec{d} = \vec{v}_i\Delta t + \frac{1}{2}\vec{a}\Delta t^2$	$\Delta\vec{d}$, $\vec{v}_i$, Δt, $\vec{a}$	$\vec{v}_f$
Equation 4	$v_f^2 = v_i^2 + 2a\Delta d$	v_f, v_i, a, Δd	Δt
Equation 5	$\Delta\vec{d} = \vec{v}_f\Delta t - \frac{1}{2}\vec{a}\Delta t^2$	$\Delta\vec{d}$, $\vec{v}_f$, Δt, $\vec{a}$	$\vec{v}_i$



PROJECTILE MOTION

1. Projectile launched horizontally



v_{ix} = given (horizontal component only)
$v_{iy} = 0$ (no vertical component)
$a_y = -9.8\ m/s^2$ (negative since $+y$ is up)
Δd_y = negative (projectile goes down)

Solve for time of flight:

$$\Delta d_y = \cancel{v_{iy}}\Delta t + \frac{1}{2}a_y(\Delta t)^2$$

$$\Downarrow$$

$$\Delta d_y = \frac{1}{2}a_y(\Delta t)^2$$

$$\Downarrow$$

$$\frac{2 \cdot \Delta d_y}{a_y} = \Delta t^2$$

$$\Downarrow$$

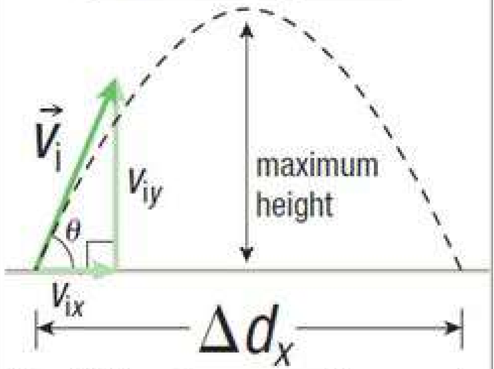
$$\sqrt{\frac{2 \cdot \Delta d_y}{a_y}} = \Delta t$$

Solve for range/horizontal distance:

$$v = \frac{\Delta d}{\Delta t} \rightarrow v_{ix} = \frac{\Delta d_x}{\Delta t}$$

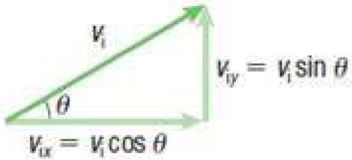
$$\Delta d_x = v_{ix} \cdot \Delta t$$

2. Projectile from ground to ground



$\Delta d_y = 0$ (since it goes ground to ground)
$v_{fy} = 0$ (at max height)

Solve for v_{ix} and v_{iy}



Solve for time of flight:

$$\cancel{\Delta d_y} = v_{iy}\Delta t + \frac{1}{2}a_y(\Delta t)^2$$

**Note: will get two roots,
one root will be zero,
the other root will have a value for time*

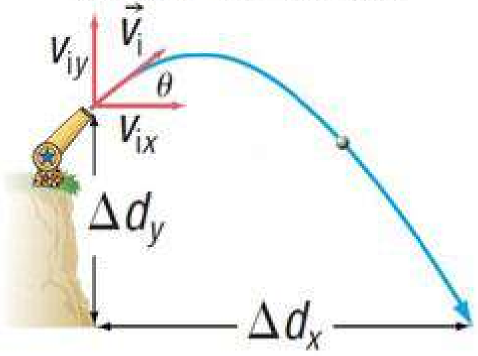
Solve for range/horizontal distance:

$$\Delta d_x = v_{ix} \cdot \Delta t$$

Solve for Δd_y or max height:

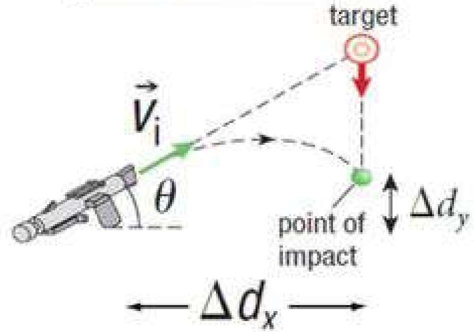
$$\cancel{v_{fy}}^2 = v_{iy}^2 + 2a_y\Delta d_y$$

3. Projectile from height to ground



Δd_y = negative (projectile goes down)

4. Projectile from ground to height



Δd_y = positive (projectile goes up)

Solve for v_{ix} and v_{iy}

Solve for time of flight:

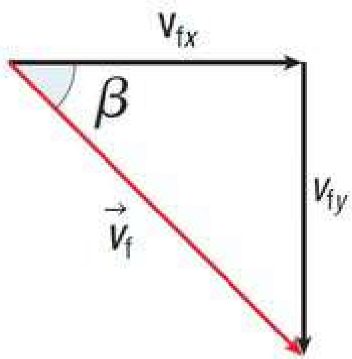
$$\Delta d_y = v_{iy}\Delta t + \frac{1}{2}a_y(\Delta t)^2$$

**Note: will get a quadratic equation, take the positive value for time*

Solve for range/horizontal distance:

$$\Delta d_x = v_{ix} \cdot \Delta t$$

Solve for velocity while landing using components:



$v_{fx} = v_{ix}$ (same velocity in the x-direction)

$$v_{fy}^2 = v_{iy}^2 + 2a_y\Delta d_y$$

or

$$v_{fy} = v_{iy} + a_y\Delta t$$

$$v_f = \sqrt{(v_{fx})^2 + (v_{fy})^2}$$

$$\beta = tan^{-1}\left(\frac{opp}{adj}\right) = tan^{-1}\left(\frac{|v_{fy}|}{|v_{fx}|}\right)$$