

1 | Givens

- With v_o being the initial velocity of the projectile as a vector;
- With v_x and v_y being the x and y components of the initial velocity vector of the projectile;
- With v_1 being the initial downwards velocity of the target;
- With x_o and h_o being the initial horizontal distance between the projectile and target, and the initial height of the target, respectively;

2 | Proof

$$\begin{cases} h_{\text{projectile}}(t) &= v_y t - \frac{1}{2}gt^2 \\ h_{\text{object}}(t) &= h_o - v_1 t - \frac{1}{2}gt^2 \end{cases}$$

Because we want to know the time (t) when $h_{\text{projectile}}$ and h_{object} are equal, we will set them equal and get a good equation:

$$\begin{aligned} v_y t - \frac{1}{2}gt^2 &= h_o - v_1 t - \frac{1}{2}gt^2 \\ v_y t &= h_o - v_1 t \end{aligned}$$

Now that we have a nice equation, we can also solve for t . We will do this by using the $x(t)$ equation:

$$\begin{aligned} x_o &= v_x t \\ t &= \frac{x_o}{v_x} \end{aligned}$$

We can plug t into our v_y equation now:

$$\begin{aligned} v_y \frac{x_o}{v_x} &= h_o - v_1 \frac{x_o}{v_x} \\ x_o \frac{||v_o|| \sin \theta}{||v_o|| \cos \theta} &= h_o + \frac{v_1 x_o}{||v_o|| \cos \theta} \end{aligned}$$