12.9: Summary

This following table summarizes the formulæ for a projectile initially at the origin, fired with initial velocity v_0 at an angle θ from the horizontal.

Table 9-1. Summary of formulæ for projectile motion.

Quantity	Formula
$x(t)$	$x = (v_0 \cos\theta)\, t$
$y(t)$	$y = -\frac{1}{2} g t^2 + (v_0 \sin\theta)\, t$
$y(x)$	$y(x) = \left(-\frac{g}{2 v_0^2 \cos^2\theta} \right) x^2 + (\tan\theta) x$
Time in flight	$t_f = \frac{2}{g} v_0 \sin\theta$
Range at angle θ	$R = \frac{v_0^2}{g} \sin 2\theta$
Max. range (at $\theta = 45^\circ$)	$R_{\max} = \frac{v_0^2}{g}$
Angle needed to hit target at range R for fixed v_0	$\theta = \frac{1}{2} \sin^{-1}\left(\frac{gR}{v_0^2} \right)$
Speed needed to hit target at range R for fixed θ	$v_0 = \sqrt{\frac{gR}{\sin 2\theta}}$
Max. altitude	$h = \frac{v_0^2 \sin^2\theta}{2g}$
Speed needed to hit target at (x_t, y_t) for fixed θ	(x_t, y_t) for fixed θ & $v_0 = \sqrt{\frac{g x_t}{2\left(\tan\theta - \frac{y_t}{x_t}\right)\cos^2\theta}}$
Angle needed to hit target at (x_t, y_t) for fixed v_0	$x_t \sin 2\theta - 2 y_t \cos^2\theta = \frac{g x_t^2}{v_0^2}$

Note that this last expression must be solved iteratively for θ.