2 Kinematics of Projectile Motion

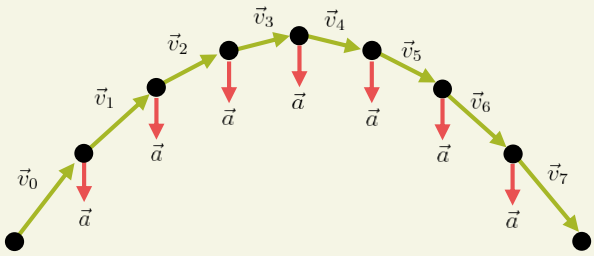
Projectile Motion

A *projectile* is an object that moves in two dimensions under the influence of only gravity. The acceleration is that of *free fall*:

$$\vec{a} = (g, \text{vertically downward})$$

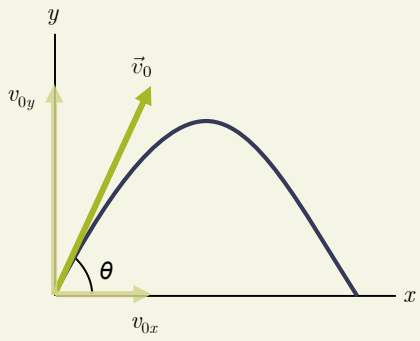
The trajectory of a projectile is a *parabola*, which you can see in the below time-lapse photograph of a bouncing ball.

A motion diagram shows that this trajectory is due to the vertically downward acceleration:



Coordinate System

Although where you put the origin is arbitrary, it is standard to arrange your coordinate system for projectile motion such that the y axis is vertical with positive upward and the x axis is horizontal with positive to the right. We'll assume that the projectile is launched to the right at an angle of θ with initial speed v_0 as shown below.



In this coordinate system, the initial velocity $\vec{\boldsymbol{v}}_{\boldsymbol{0}}$ has components

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

The components of the acceleration $\vec{\boldsymbol{a}}$ are

$$a_{0x} = 0$$
$$a_{0y} = -g$$

Model: Projectile Motion

With the coordinate system described above, the mathematical model for an object undergoing projectile motion is:

Horizontal Motion

Constant velocity

Position $x_f = x_i + v_{ix}\Delta t$

Velocity $v_{fx} = v_{ix} = \text{constant}$

Vertical Motion

Constant acceleration – free fall

Position $y_f = y_i + v_{iy}\Delta t - \frac{1}{2}g\Delta t^2$

Velocity $v_{fy} = v_{iy} - g\Delta t$