Projectile Motion

Projectiles

A *projectile* is any object that is given an initial velocity and then follows a path determined entirely by the effects of gravitational acceleration and air resistance.

(In this class, we will assume no air resistance.)

Equations of Motion for Projectiles

For projectiles (cannon balls, footballs, baseballs, soccer balls) *the motion of the object in the horizontal and vertical direction are independent of one another*.

Therefore, the motion of projectile can be described by separate equations of motion for the *x* and *y* directions.

Projectile Motion in Two Dimensions (2D)

Horizontal Motion (x-direction)

No acceleration in the *x*-direction so there is constant velocity and the equations of motion are

$$\Delta x = v_x t \quad (x\text{-displacement})$$

$$v_x = v_{x_i} \quad (x\text{-velocity})$$

Projectile Motion in Two Dimensions (2D)

Vertical Motion (y-direction)

There is gravitational acceleration in the *y*-direction so the equations of motion are those for uniform acceleration.

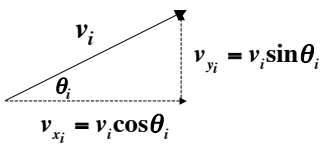
$$\Delta y = -\tfrac{1}{2} g t^2 + v_{y_i} t \quad (y\text{-displacement})$$

$$v_y = -gt + v_{y_i} \quad (y\text{-velocity})$$

$$\text{On Earth: } g = 9.8 \ \frac{\text{m}}{\text{s}^2}$$

Determining Initial Velocity Components

The initial velocities in the *x* and *y* directions are found from the initial velocity of the object and the angle at which the object is launched.



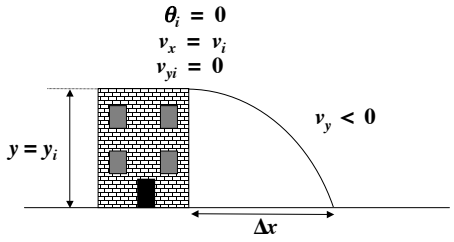
More Equations for Projectiles

Because projectiles are uniformly accelerating in the *y*-direction:

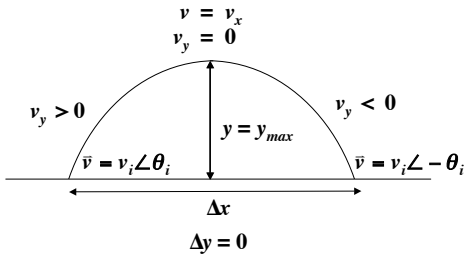
$$\Delta y = \left(\frac{v_{y_i} + v_y}{2} \right) t$$

$$v_y^2 = v_{y_i}^2 - 2g\Delta y$$

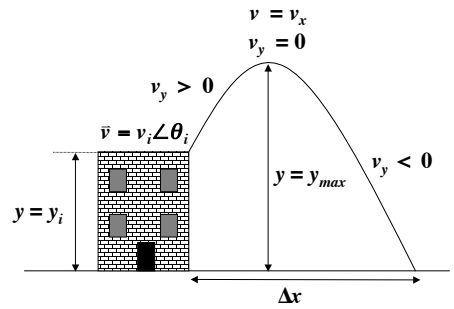
Horizontally Launched Projectile



Ground-to-Ground Projectile



Projectile Launched From a Height at an Angle



Maximum Height of a Projectile

When a projectile reaches its maximum height, the *y*-component of the velocity is zero and the speed is equal to the *x*-component of the initial velocity.