Solving Angle-Launched Projectile Problems

Lesson Notes

What is an Angle-Launched Projectile?

Angle-launched projectiles are objects projected at an angle to the horizontal. Their motion begins with both an x- and y-velocity component.

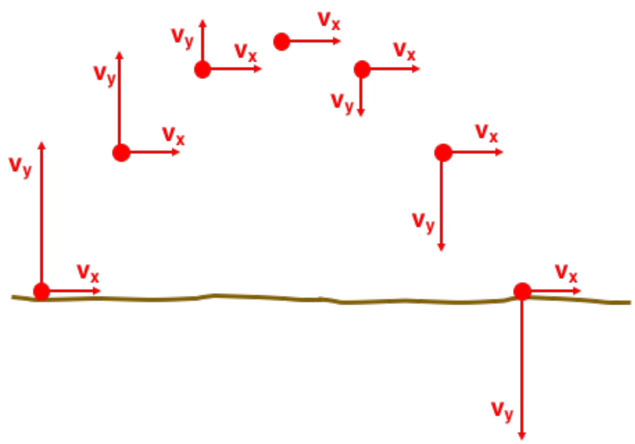
- Projectiles have no horizontal acceleration and a vertical acceleration of 9.8 m/s/s, ↓.

  $\mathbf{a_x = 0\ m/s/s \quad a_y = -9.8\ m/s/s}$

- At the highest point (the "peak"), the vertical velocity is 0 m/s.

  $\mathbf{v_{y\text{-peak}} = 0\ m/s}$

- Projectiles have the same v_x and v_y values when at the same height.



Problem-Solving Tips and Strategies

Projectile problems must be solved using two sets of kinematic equations. Horizontal and vertical motion parameters must be kept separate from one another.

Horizontal: $d_x = v_{ox} \bullet t$

Vertical: $d_y = v_{oy} \bullet t - 4.9 \bullet t^2$ $v_{fy} = v_{oy} - 9.8 \bullet t$

$v_{fy}^2 = v_{oy}^2 - 19.6 \bullet d_y$ $d_y = [\ (v_{oy} + v_{fy})/2\ ] \bullet t$

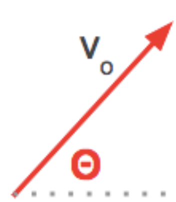
Strategy:

1. Read the problem carefully. Diagram it.
2. ID known values; relate to corresponding symbol.
3. ID the unknown value; use the variable symbol.
4. Select the appropriate equation to use.
5. Substitute known values; solve for unknown.

Original Velocity Components

Projectile problems often state the original velocity (v_o) and the angle (θ). Begin by resolving v_o into x- and y-components (v_{ox} and v_{oy}).

Be careful of what values you enter into equations - v_o, v_{ox}, v_{oy}. Most kinematic equations require v_{ox} and v_{oy}.



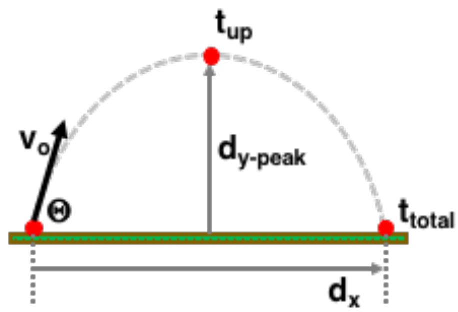
$v_{ox} = v_o \bullet \cos\Theta$

$v_{oy} = v_o \bullet \sin\Theta$

where Θ is the launch angle measured with the ground.

Example 1

A projectile is launched at 32.1 m/s and 52.6° above the horizontal. Determine the time in the air, the horizontal displacement, and the peak height.



Given: $v_o = 32.1$ m/s $\Theta = 52.6°$

Find: t_{total}, d_x, and $d_{y\text{-peak}}$

$v_{ox} = v_o \cdot \cos \Theta = 32.1 \cdot \cos(52.6°) = 19.496...$ m/s

$v_{oy} = v_o \cdot \sin \Theta = 32.1 \cdot \sin(52.6°) = 25.500...$ m/s

$v_{fy} = v_{oy} - 9.8 \cdot t_{up}$ ➡ $0 \text{ m/s} = 25.5 - 9.8 \cdot t_{up}$ ➡

$t_{up} = 25.5/9.8 =$ **2.602 s** ➡ $t_{total} = 2 \cdot t_{up} =$ **5.204 s**

$d_x = v_{ox} \cdot t$ ➡ $d_x = (19.496... \text{ m/s}) \cdot (5.204... \text{ s})$ ➡

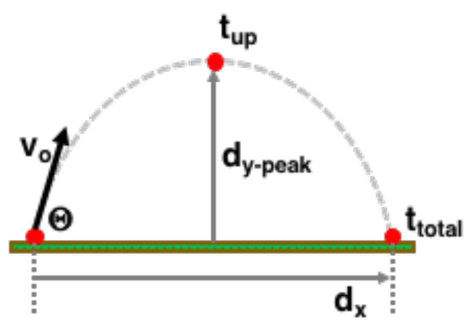
d_x = 101 m (101.4655… m)

$d_y = [(v_{oy} + v_{fy})/2] \cdot t$ ➡ $V_{fy} = 0$ m/s; $t = t_{up} = 2.602...$ s ➡

$d_{y\text{-peal}} = [(25.500... + 0)/2] \cdot (2.602... \text{ s})$ ➡ **$d_{y\text{-peak}}$ = 33.2 m**

Example 1 Summary

Given: v_o and Θ **Find**: t_{total}, d_x, and $d_{y\text{-peak}}$



1. Calculate the x- and y-components of v_o using …

   $v_{ox} = v_o \cdot \cos \Theta$ $v_{oy} = v_o \cdot \sin \Theta$

2. Calculate t_{up} using …

   $v_{fy} = v_{oy} - 9.8 \cdot t_{up}$ where $v_{fy} = 0$ m/s

3. Calculate total knowing $t_{total} = 2 \cdot t_{up}$

4. Calculate d_x using …

   $d_x = v_{ox} \cdot t$ where the t is t_{total}

5. Calculate $d_{y\text{-peak}}$ using …

   $d_{y\text{- peak}} = [(v_{oy} + v_{fy})/2] \cdot t_{up}$ where $v_{fy} = 0$ m/s