# PROJECTILE MOTION

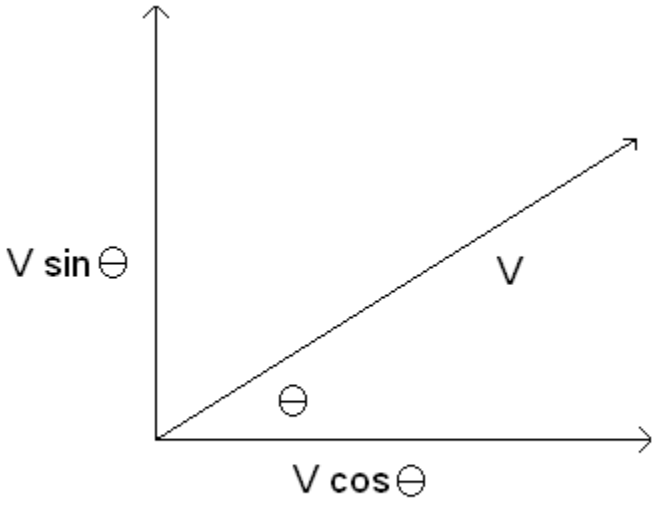
## *Definitions*

**Projectile -** Any body in freefall that has a horizontal aspect to its motion.

**Trajectory -** The curve that describes the motion of a body in space.

## *Motion in Two Dimensions*

The **x** and **y** components of motion are completely separable. At any time, a projectiles velocity can be divided up in the following manner.



# ***Projectile Motion Equations***

## Acceleration

$A_x = 0$

$A_y = -g$

## Velocity

$V_x = V(\cos \theta)$

$V_y = V(\sin \theta) + A_y t$

$= V(\sin \theta) - gt$

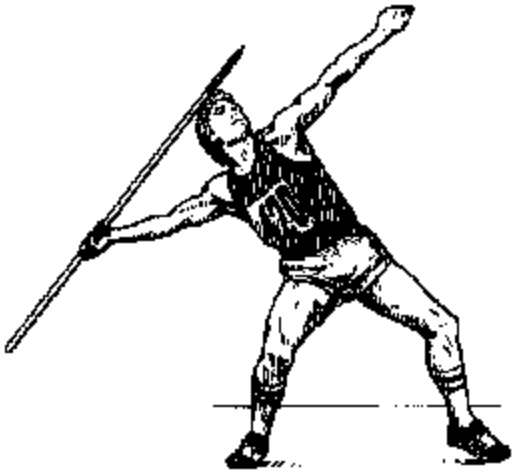
## Position

$P_x = P_{x0} + V(\cos \theta)t$

$P_y = P_{y0} + V(\sin \theta)t + 0.5A_y t^2$

$= P_{y0} + V(\sin \theta)t - 0.5gt^2$

# ***Javelin Example***



A javelin thrower releases a javelin 1.5 meters from the ground at an angle of 48°. If the initial velocity of the javelin is 25 m/s, what is the distance the javelin travels.

Components of the initial velocity:

$V(\cos\theta) = 25(\cos(48°)) = 16.73$ m/s

$V(\sin\theta) = 25(\sin(48°)) = 18.58$ m/s

Initial and final position values:

$P_{x0} = 0$ m; $P_{y0} = 1.5$ m; $P_y = 0$ m;

Use the following equation to determine t:

$P_y = P_{y0} + V(\sin\theta)t - 0.5gt^2$

$0 = 1.5 + 18.58t - 4.9t^2$

Using the quadratic equation to solve for t:

$t = \underline{3.871 \text{ s}}$

We can now solve for $P_x$:

$P_x = P_{x0} + V(\cos\theta)t = 0 + 16.73(3.871) = \underline{64.76 \text{ m}}$

Find the maximum height of the javelin.

Remembering that the vertical velocity is zero when the javelin reaches its highest point.

$V_y = V(\sin \theta) - gt$

$0 = 18.58 - 9.8t \qquad t = 1.896 \text{ s}$

We can now solve for $P_{ymax}$

$$\begin{aligned} P_{ymax} &= P_{y0} + V(\sin \theta)t - 0.5gt^2 \\ &= 1.5 + 18.58(1.896) - 4.9(1.896)^2 \\ &= \underline{19.11 \text{ m}} \end{aligned}$$