

# Curvilinear Kinematics

## WHAT IS CURVILINEAR KINEMATICS?

Curvilinear kinematics refers to 2-D motion, also known as *projectile motion*.

The kinematics of a particle is characterized by specifying at any given time  $t$ , the particle's position, velocity, and acceleration.

The **position** of an object is defined by a vector  $\vec{r}(x, y, z)$ . The **velocity** of an object is defined as the change in position relative to change in time and can be written as:

$$\vec{v} = \frac{d\vec{r}}{dt} = \left( \frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt} \right)$$

The **acceleration** of an object is defined as the change in velocity relative to time, and can be written as:

$$\vec{a} = \frac{d\vec{v}}{dt}$$

## CONSTANT ACCELERATION MODEL

If an object is moving in a projectile motion at a constant acceleration, the kinematic relationships can be written:

For horizontal motion:

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

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

For vertical motion:

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

$$v_{fy} = v_{fi} - g \Delta t$$

## SAMPLE PROBLEMS

1. A soccer player is running across the field toward the opponent's net. She kicks the ball towards the net with a speed of 14.7 m/s at an angle of  $28.0^\circ$  above the ground. How long was the ball in the air?
  
2. A dart is thrown horizontally at 8.10 m/s at a dart board. When it hits the board, it is 0.299m below its target. How far away from the board was the dart when it was thrown?
  
3. A bird is flying east at a speed of 7.20 m/s at an elevation of 23.0 m. The bird then poops, and it lands on a truck which is moving east along a level road with constant speed. At the instant the poop is released, the truck is a horizontal distance of 1.25 m in front of the bird. Find the speed of the truck and the time of flight of the poop. Assume that the truck is 3.00 m high.