

Rectilinear Kinematics

WHAT IS RECTILINEAR KINEMATICS?

Rectilinear kinematics refers to straight line 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 it 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 it can be written as:

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

CONSTANT ACCELERATION MODEL

If an object is moving in a straight line at a constant acceleration, the kinematic relationships can be written as:

$$s_f = s_i + v_{is}\Delta t + \frac{1}{2} a \Delta t^2$$

$$v_f = v_i + a \Delta t$$

$$v_f^2 = v_i^2 + 2 a (s_f - s_i)$$

where:

- s_i is the initial position;
- s_f is the final position;
- v_i is the initial velocity;
- v_f is the final velocity;
- a is the acceleration.

SAMPLE PROBLEMS

- 1) A girl is running across a track. The girl accelerates at 6.00 m/s^2 over a distance of 6.90 m . She runs until her speed is 24.8 m/s and continues at this speed. What was the girl's initial speed?

- 2) A motorist drives along a straight road at a constant speed of 15.0 m/s . Just as she passes a parked police officer vehicle, the officer starts to accelerate at 2.00 m/s^2 to overtake her.
 - a) Determine the time it takes the police officer to reach the motorist.
 - b) Find the speed of the officer as he overtakes the motorist
 - c) What is the total displacement of the officer as he overtakes the motorist?

- 3) A test rocket is fired vertically upward from a well. A catapult gives it initial speed of 80.0 m/s at ground level. Its engines then fire, and it accelerates upward at 4.00 m/s^2 until it reaches an altitude of 1000.0 m . At that point, its engines fail, and the rocket goes into free fall.
 - a) How long is the rocket in motion above the ground?
 - b) What is its maximum altitude?
 - c) What is its velocity just before it collides with the Earth?