Lecture 5: Constant Acceleration

Warm-Up Activity

Which of these equations are valid for an object moving with constant acceleration? Choose all that apply, and WRITE BIG!

(A) $\vec{a}(t) = a\hat{x}$

(B) $\vec{v}(t) = \left[v_i + a_0\left(t - \frac{t^2}{T}\right)\right]\hat{x}$

(C) $v_f^2 = v_i^2 + 2a\Delta x$

(D) $\vec{x}(t) = \left[x_i + v_i t + \frac{1}{2}at^2\right]\hat{x}$

(E) None of the above.

A Model for Motion

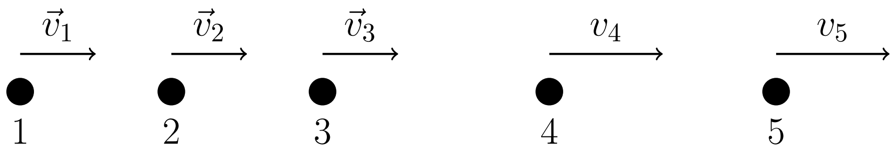
Quantities

- Position: $\vec{r}$
- Velocity: $\vec{v} = \frac{d\vec{r}}{dt}$
- Acceleration: $\vec{a} = \frac{d\vec{v}}{dt}$

Assumptions

- Use the Particle Model

Motion Diagram



Constant Acceleration

The *constant-acceleration* equations (kinematics):

- $a(t) = a$
- $v(t) = v_i + at$
- $x(t) = x_i + v_i t + \frac{1}{2}at^2$

L5-1: A Falling Rock

You drop a rock from a bridge that is 45 m above the water.

- What assumptions should we make about the motion?
- What interesting quantities can we ask about?

Acceleration in Two Dimensions

- What if we have an object that moves (with constant acceleration) in two directions?
- We can treat the motion in each direction independently!

$$a_x(t) = a_x \qquad a_y(t) = a_y$$

$$v_x(t) = v_{ix} + a_x t \qquad v_y(t) = v_{iy} + a_y t$$

$$x(t) = x_i + v_{ix} t + \frac{1}{2} a_x t^2 \qquad y(t) = y_i + v_{iy} t + \frac{1}{2} a_y t^2$$

- What if the acceleration in one direction is equal to zero?
- What if the acceleration in the y-direction is only due to gravity?

L5-2: A Thrown Rock

- You throw a rock across a flat field.
- The rock's initial speed is v, thrown at an angle θ above the horizontal.
- The rock lands a distance d away from you.

  (1) Sketch a diagram to help you find the x- and y-components of the rock's velocity in terms of v and θ.

  (2) Write an equation that would allow you to find the amount of time that the ball is in the air.

  (3) How is this time related to the amount of time the ball takes to reach its highest point above the ground?

Main Ideas

- We can use the kinematics equations to solve for any quantity of interest when the acceleration is constant.
- Motion in 2 dimensions can be broken down into independent motion in each dimension.