

Class 5: More on constant acceleration motion (1D)

Vector and Scalar

Review

If v is given as a function of t : $a = \frac{dv}{dt}$

If v is given as a function of x : $a = v \frac{dv}{dx}$

$$a_x = \text{constant}$$



$$v_{xf} = v_{xi} + a_x t$$

$$x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2$$

Dimension check

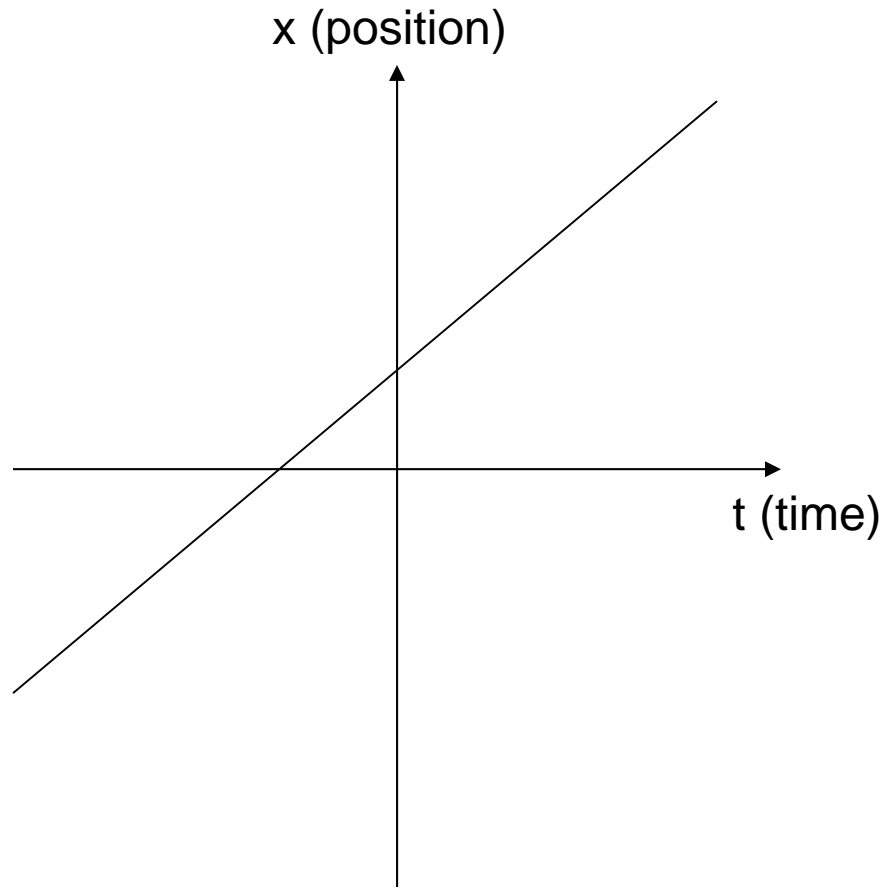
$$a_x = v_x \frac{dv_x}{dx}$$

$$v_{xf} = v_{xi} + a_x t$$

$$x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2$$

Are units consistent in these equations?

Constant velocity – a particular case of constant acceleration



$$v_{xf} = v_{xi} + a_x t$$

$$x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2$$

$$\Downarrow a_x = 0$$

$$v_{xf} = v_{xi} = \text{constant } v_x$$

$$x_f = x_i + v_x t$$

Meaning of each term

½ and square come from integration.

$$x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2$$

First guess: Initial position

Better guess: Initial position + initial velocity \times time, but this will underestimate because it is accelerating

Fine adjustment to account for acceleration

Taylor expansion of position as function of time:

$$x = \underbrace{x_{t=0}}_{=x_i} + \underbrace{\left. \frac{dx}{dt} \right|_{t=0}}_{=v_{xi}t} t + \underbrace{\left. \frac{1}{2!} \frac{d^2x}{dt^2} \right|_{t=0}}_{=\frac{1}{2}a_i t^2} t^2 + \underbrace{\left. \frac{1}{3!} \frac{d^3x}{dt^3} \right|_{t=0}}_{=0 \text{ if acceleration} = \text{constant}} t^3 + \dots$$

Constant acceleration motion is the first approximation of any complex motion.

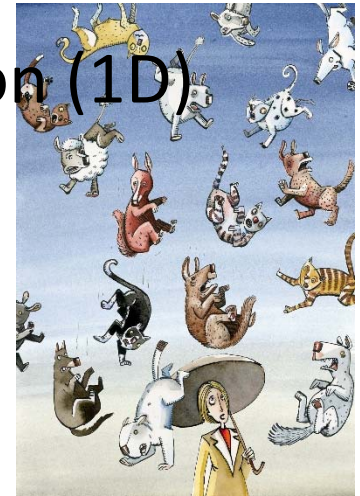
Free falling is a constant acceleration motion (1D)

$a_y = \text{constant} = 9.8 \text{ m/s}^2$ for any object

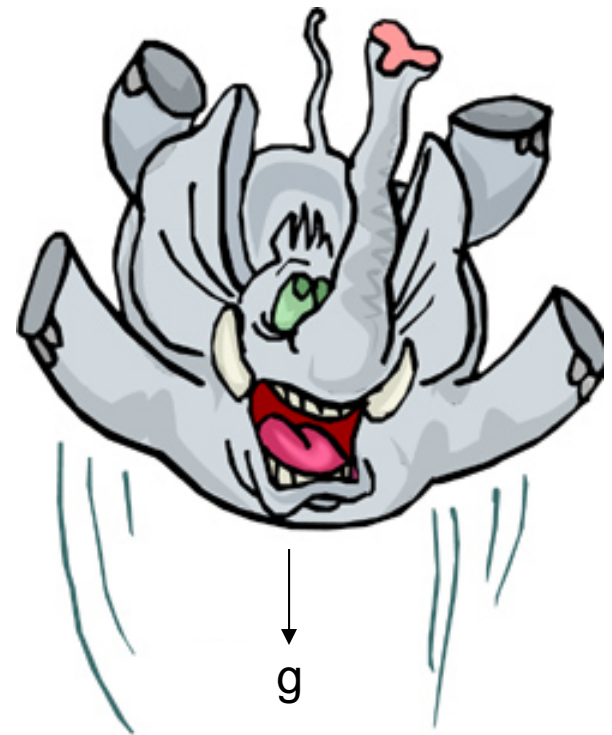


$$v_{yf} = v_{yi} + a_y t$$

$$y_f = y_i + v_{yi} t + \frac{1}{2} a_y t^2$$



$$g = 9.8 \text{ m/s}^2$$



Constant acceleration motion (1D)

Example problem (Serway & Jewette 9th Ed. Prob. 2-67)

An elevator moves downward in a tall building at a constant speed of 5.00 m/s. Exactly 5.00s after the top of the elevator car passes a bolt loosely attached to the wall of the elevator shaft, the bolt falls from rest. (a) At what time does the bolt hit the top of the still descending elevator? (b) Estimate the highest floor from which the bolt can fall if the elevator reaches the ground floor before the bolt hits the top of the elevator.

Class Work Problem (CW3 Jan 26, 2015)

A basketball player standing under the hoop shoots the ball straight up with an initial velocity of $v_0 = 3.75$ m/s from 2.5 m above the ground.

(a) What is the maximum height, h (in meters), above the launch point the basketball will achieve?

(b) On his first attempt, the ball doesn't make it high enough to reach the hoop. If the hoop is at 3.5 m above the ground, what is the minimum velocity (in m/s) with which he must launch his second attempt to reach the hoop?

