Elevator and Bolt problem
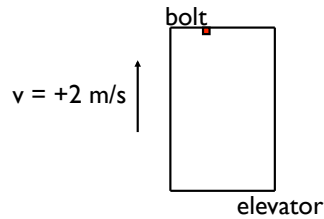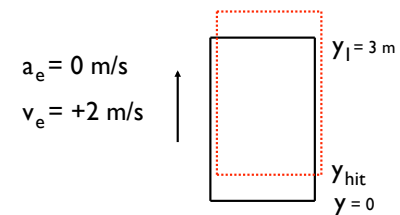
A 3 meter tall elevator moving at 2 m/s upward has a bolt come loose at t=0. The bolt "freefalls" for a period of time and finally hits the elevator's floor. How far has the elevator's floor moved during the time the bolt free fell?

bolt

$v = +2$ m/s

elevator

1.)

Elevator (tracking the floor)

$y_1 = 3$ m

$a_e = 0$ m/s

$v_e = +2$ m/s

y_{hit}

$y = 0$

$y_{hit} = y_o + v_o t + \frac{1}{2} a_e t^2$

$= 0 + (2 \text{ m/s}) t + 0$

$\Rightarrow y_{hit} = 2t$

3.)

Sketches of elevator and bolt

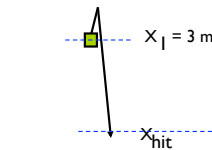elevator

$a_e = 0$ m/s

$v_e = +2$ m/s

$x_1 = 3$ m

x_{hit}

$X = 0$

shifted for ease
of viewing

bolt

$x_1 = 3$ m

x_{hit}
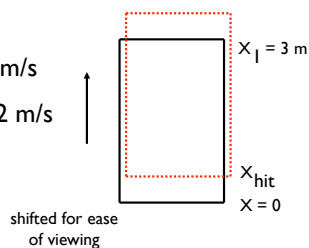
$v_{b, initial} = +2$ m/s

$a_{bolt} = -9.8$ m/s^2

Common factors between the two parts?

Bolt and floor will have same "final" coordinate.

Bolt and floor will have have same "time of flight."

2.)

---

tracking bolt

$y_1 = 3$ m
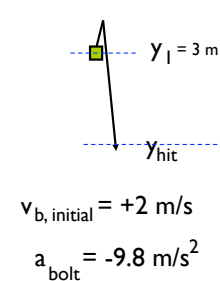
y_{hit}

$v_{b, initial} = +2$ m/s

$a_{bolt} = -9.8$ m/s^2

$y_{hit} = y_1 + v_o t + \frac{1}{2} a_g t^2$

$= (3 \text{ m}) + (2 \text{ m/s}) t + \frac{1}{2} (-9.8 \text{ m/s}^2) t^2$

$= 3 + 2t - 4.9t^2$

4.)

Equating the two y(hit) expressions yields: $y_{hit} = 3 + 2t - 4.9t^2$

$$y_{hit} = 2t$$

so

$$2t = 3 + 2t - 4.9t^2$$

$$\Rightarrow \quad 4.9t^2 = 3$$

$$\Rightarrow \quad t = .78 \text{ seconds}$$

The elevator is in motion for a time .78 seconds between the time the bolt lets loose and hits the floor, and during that time the elevator floors moves:

$$y_{hit} = 2t$$

$$= (2 \text{ m/s})(.78 \text{ sec})$$

$$= 1.56 \text{ m}$$

5.)