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PHY2053 Health, Summer C 2016

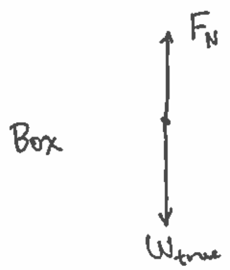
Quiz 2

Date: Thursday, June 2, 2016

Problem 1: A box of weight W_{true} is placed on a floor scale inside an elevator. The elevator begins to accelerate at a rate of $a = 4.0$ m/s^2. While accelerating, the reading on the scale is $W_{scale} = 95$ N. We know that $W_{scale} < W_{true}$.

(a) In what direction is the elevator accelerating? Explain your answer.

(b) What is the mass of the box? Hint: how is the reading on the scale related to the normal force acting on the box?



± depends on direction of acceleration.

$$F_N - W_{true} = \pm ma$$

$$\hookrightarrow W_{scale} = \boxed{F_N = W_{true} \pm ma.}$$

(a) As $W_{scale} < W_{true}$, we choose the "−" sign, so we are accelerating downward.

(b) $W_{scale} = W_{true} - ma$; $W_{true} = mg$.

$$\longrightarrow W_{scale} = mg - ma = m(g-a).$$

so $$\boxed{m = \frac{W_{scale}}{g-a} = \frac{95\ \text{N}}{10-4} = 15.8\ \text{kg}}$$

(Problem 2 on the next page)

Problem 2: Imagine that, instead of dropping a piece of chalk in lecture on Wednesday, Jonathan had decided to drop a light bulb onto the floor (gasp!). Let's investigate the possibly destructive consequences of such an action.

Assume that a light bulb has mass $m = 0.3$ kg and is dropped from rest a height of 2 m above the floor. The floor, being made of hard tiling, stops the light bulb in a very short time of $\Delta t = 0.06$ s after it hits the floor. The bulb *does not rebound.*

Remember that momentum is a vector!

(a) What is the momentum of the light bulb *just before it hits the floor*?

(b) What is the change in the light bulb's momentum after it lands?

(c) The light bulb is designed to withstand impact forces up to $F_{\text{max}} = 40$ N. Does the bulb break when it hits the floor? Support your answer with numerical evidence!

(a) It falls from rest from a height of $-\Delta y = 2$ m. So the speed is

$$v_f^2 = -2g\Delta y \longrightarrow v_f = \sqrt{-2g\Delta y} = \sqrt{2(10)(2)}$$

$$\vec{v}_f = -6.3 \text{ m/s}$$

Thus $\boxed{\vec{p}_i = m\vec{v}_f = 1.9 \text{ kg m/s down}}$

(b) After it hits the floor, $\vec{p}_f = 0$. So

$$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = 0 - \vec{p}_i$$

$$\longrightarrow \boxed{\Delta\vec{p} = 1.9 \text{ kg m/s up}}$$

(c) From the definition of impulse,

$$\Delta\vec{p} = \vec{F}_{net}\Delta t \longrightarrow \vec{F}_{net} = \frac{\Delta\vec{p}}{\Delta t} = \frac{1.9 \text{ kg m/s}}{0.06 \text{ s}} \text{ up}$$

$$\vec{F}_{net} = 31.6 \text{ N up}$$

This (average) force is less than F_{max}, so it $\boxed{\text{does not break.}}$