Apparent Weight in an Elevator

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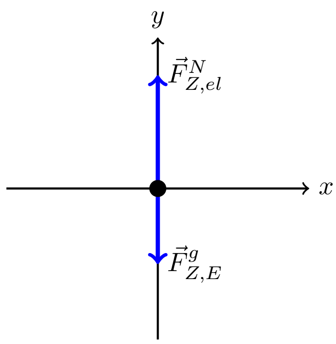
XX-1: Apparent Weight in an Elevator

Zach, whose mass is 80 kg, is on an elevator descending at 12 m/s. The elevator takes 3.0 s to brake to a stop at the ground floor.

(a) Draw a free-body diagram for Zach. Which force is Zach's apparent weight?



The floor of the elevator pushes up on Zach with the normal force $\vec{F}^N_{Z,el}$. In turn, he pushes back on the floor with an equal and opposite force, $\vec{F}^N_{el,Z}$ (this is Newton's 3rd law). If the floor were a scale, this is the force that it would measure—it doesn't magically know the force of gravity on Zach, $\vec{F}^g_{Z,E}$ (which some might refer to as Zach's actual weight); it can only go off of what it feels from Zach's feet pushing on it. The normal force is Zach's apparent weight.

(b) What is Zach's apparent weight before the elevator starts braking?

Before braking, the elevator descends at a constant speed. Therefore

$$\begin{aligned} F_y^{net} &= ma_y = 0 \\ F^N_{Z,el} - F^g_{Z,E} &= 0 \\ F^N_{Z,el} &= F^g_{Z,E} = mg = (80\text{ kg})(9.8\text{ m/s}^2) \approx 780\text{ N}. \end{aligned}$$

Zach's apparent weight is 780 N while in an inertial reference frame.

(c) What is Zach's apparent weight while the elevator is braking?

The elevator must decelerate from 12 m/s to 0 m/s over 3.0 seconds. On average, that means

$$a_y = \frac{\Delta v}{\Delta t} = \frac{12\text{ m/s}}{3.0\text{ s}} = 4.0\text{ m/s}^2.$$

Now, the net force is nonzero, and we find

$$\begin{aligned} F_y^{net} &= ma_y \\ F^N_{Z,el} - F^g_{Z,E} &= ma_y \\ F^N_{Z,el} &= ma_y + F^g_{Z,E} = m(a_y + g) = (80 \text{ kg})(4.0 \text{ m/s}^2 + 9.8 \text{ m/s}^2) \approx 1100 \text{ N}. \end{aligned}$$

Zach's apparent weight is 1100 N while in the braking elevator.