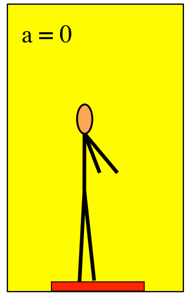
Problem 5.35

A very thin man stands on a scale in an elevator.



a.) Assuming the man's mass is 72.0 kg, what does the scale read before the elevator begins to move?

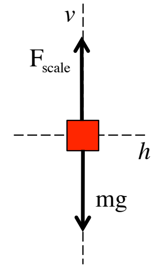
With no acceleration, the scale will just read "mg," or:

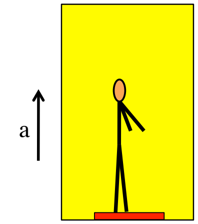
$$\begin{aligned} F_{scale} &= mg \\ &= (72.0\text{ kg})(9.80\text{ m/s}^2) \\ &= 706\text{ N} \end{aligned}$$

b.) The elevator ascends from rest to 1.20 m/s in .8 seconds. What does the scale register during this interval?

We need to know the acceleration, and as always when a time is given, our first thought should be to kinematics. Specifically, as viewed on the next page:

Looking at the forces on the man, we can do a f.b.d. (see to right) and use N.S.L. to write:

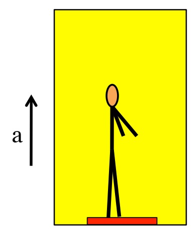




$$\underline{\sum F_v :}$$

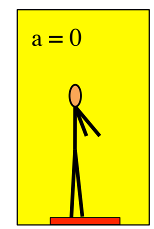
$$\begin{aligned} F_{scale} - mg &= ma \\ \Rightarrow \quad F_{scale} &= mg + ma \\ &= (72.0\text{ kg})(9.80\text{ m/s}^2) + (1.20\text{ kg})(1.50\text{ m/s}^2) \\ &= 814\text{ N} \end{aligned}$$

$$\begin{aligned} v_2 &= \cancelto{0}{v_1} + a(\Delta t) \\ \Rightarrow \quad a &= \frac{v_2}{\Delta t} \\ &= \frac{(1.20\text{ m/s})}{(.800\text{ s})} \\ &= 1.50\text{ m/s}^2 \end{aligned}$$



Preliminary Note: The normal force "N" exerted upward on the man by the scale is the same in magnitude as the force the man exerts downward on the scale as he stands on it. That downward force is what the scale "reads," and that is what we are looking for.

c.) For the next 5.00 seconds, the elevator moves with the constant velocity calculated in Part b, or 1.50 m/s. What does the scale read during this time interval?



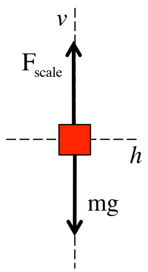
Constant velocity, whether it is 1.50 m/s or -1.50 m/s or zero m/s, means the acceleration is ZERO. If that is the case, the scale will simply read the man's actual weight "mg," or (as determined in Part a) 706 N.

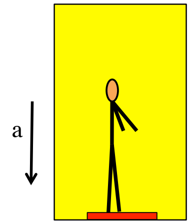
d.) Over 1.50 seconds, the elevator comes to rest. Again what does the scale read during this interval?

As before, we need the acceleration. That is:

$$\begin{aligned} \cancelto{0}{v_2} &= v_1 + a(\Delta t) \\ \Rightarrow \quad a &= \frac{-v_1}{\Delta t} \\ &= \frac{-(1.20\text{ m/s})}{(1.50\text{ s})} \\ &= -.800\text{ m/s}^2 \qquad (\text{with a magnitude of } .800\text{ m/s}^2) \end{aligned}$$

Again, the f.b.d. looks just as it did for the previous part:





And as we usually unembed the negative sign for an acceleration that is in the negative direction, relative to the coordinate axis, the "a" term is a magnitude and N.S.L. yields

$$\underline{\sum F_v :}$$

$$F_{scale} - mg = -ma$$

$$\Rightarrow \quad F_{scale} = mg - ma$$

$$= (72.0\ \text{kg})(9.80\ \text{m/s}^2) - (72.0\ \text{kg})(.800\ \text{m/s}^2)$$

$$= 648\ \text{N}$$