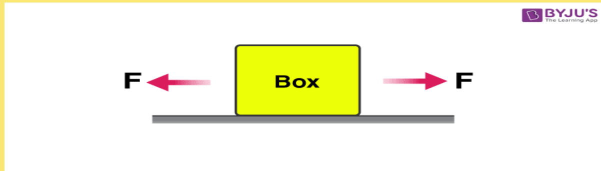


Application of force on a 150lb person standing on a scale in an elevator!

*Being 'at rest' is a tricky concept in physics as it depends upon one's reference frame!

(1) Consider standing on a scale in an elevator 'at rest'. No surprises? The scale shows your usual weight, say 150lb. There's an upward contact or **normal force** on the scale on your feet and so there must be the gravitational force (of equal magnitude) acting downwards:

We say the net force is zero and write:

$\vec{F}_{net} = m\vec{a}$ but here $\vec{F}_{net} = 0$ so there is zero acceleration (Life is good, but…)

*You feel a little rattling in the elevator so… you guess you're actually moving upward (or downward). It's difficult to tell which way if acceleration is zero and the Normal and Gravitational forces precisely cancel each other out so that $F_{net} = 0$ means a=0 also.

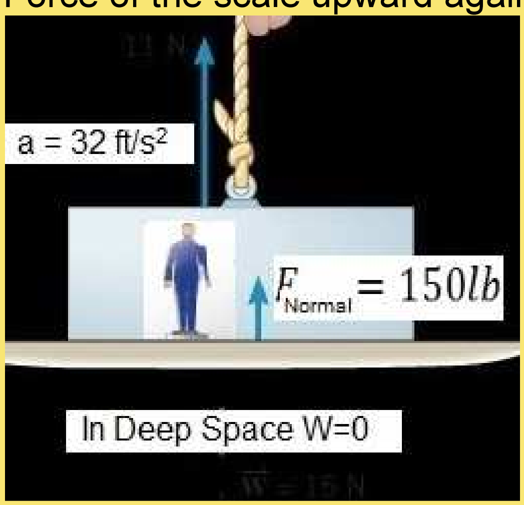
(2) Now if the normal force on the scale shows an 'apparent weight' greater than our usual weight say 180lb (to overcome gravity), then our net force is 30lb upward and non-zero. We feel this upward acceleration of about 6.4 ft/s^2 in the elevator.

(3) Suppose the elevator cable is cut and you find yourself in freefall! Looking down at the scale we see a reading of 0lb. This is often called 'weightlessness'. We definitely feel the acceleration downward which we attribute to the force of gravity.

Earth reference frame vs Outer Space reference frame!

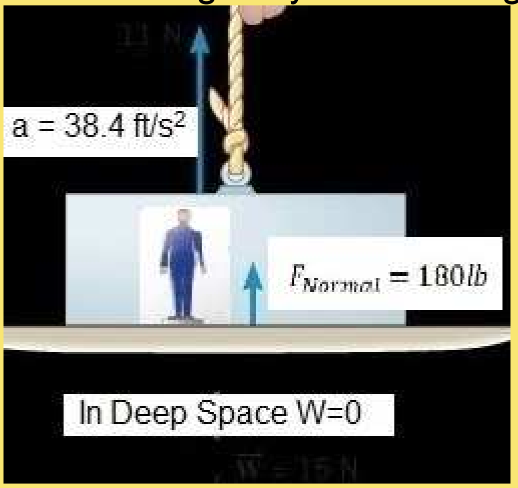
Let's look at you in this elevator from a different reference frame! You see you're actually in a box in deep space (where there is effectively no gravitational field (or force). So, you didn't know it but…

Case 1. 'We' were actually pulling on the elevator cable from the outside accelerating you thru deep space at precisely Earth's gravitational 'g' (g $\approx 32\ ft/s^2$). The only force acting on you is the Normal Force of the scale upward against your feet.



Since the scale read your usual weight, you thought you were at rest on earth!

Case 2. Here we pull even harder on the elevator cable with a resulting normal force of 180lb. You are accelerating again and it feels like the same 6.4 ft/s^2 acceleration you felt before. We (outside your elevator) see you accelerating thru space at a much greater 38.4 ft/s^2 rate. Again there is no gravity field so weight = zero.



Case 3. We stop pulling on that cable and there is zero normal force. The scale says you're 'weightless' and you feel like you're floating or if you thought you were on earth, you should be worried you're freefalling in an elevator shaft! So in the deep space reference frame you have zero acceleration and you're calm, but (if you were on the earth) a person in the elevator would say you're accelerating at that 'g' of about 32 ft/s^2 and coming to a very bad end!

Now if a nonzero net force acts on a body then the velocity (vector) $\vec{v}$ changes. Without vector notation, v has some + or – direction and in physics speed is just the positive magnitude of velocity or $|v|$. In this simplest 1-dimensional case, velocity either increases or decreases its speed. This rate of change of velocity is acceleration. *Alert – a change in the direction of the velocity vector (not necessarily its speed) is also considered an acceleration (centripetal).

The relation between force and acceleration and is given by Newton's second law. According to Newton's second law:

$\vec{F}_{net} = m\vec{a}$ vs F = ma (which only indicates direction if a negative sign is used?)

From the above relation, we can say that acceleration not only depends on the force applied but also on the mass of the body on which it is applied. In our elevator problem above (and in most all physics problems), the mass of the object remains constant. It's the force of gravity (defined in physics as 'weight') that can change depending on your location with respect to a gravitational field.

Notes: W or F_g = mg on earth which means a 150lb person has a mass of 4.6875 slugs (American unit of mass vs the metric unit of kg). So in deep space if a net force of 180 lb acted on such a person, the resulting acceleration would be 38.4 ft/s^2.