Forces - the cause of change in motion

- push or pull
- attempt to change velocity
- multiple forces combine and act at the same
  time on an object

The amount of velocity change depended on

$$\text{change in velocity} = \frac{\text{Force} \cdot \text{time}}{\text{mass}}$$

$$(m)\Delta v = \frac{F \cdot \Delta t}{m}(m)$$

$$\frac{m \cdot \Delta v}{\Delta t} = \frac{F \cdot \cancel{\Delta t}}{\cancel{\Delta t}}$$

← come back in Ch. 7

$$F = \frac{m \cdot \Delta v}{\Delta t}$$

$$\boxed{F_{NET} = m \cdot a}$$

Force = mass · acceleration

Contact Forces

* push/pull
* tension - force on an object through a rope/wire/chain
* normal force - force due to contact with a surface. Always directed perpendicularly to the surface
* friction - force between surfaces directed parallel to the surface
* spring force - force is proportional to amount of stretch/compression

on earth

$$F_g = \underline{\text{weight}} = \underbrace{\text{mass}}_{[kg]} \times \underbrace{9.8\ m/s^2}_{g}$$

Non-contact forces

Fundamental Forces:

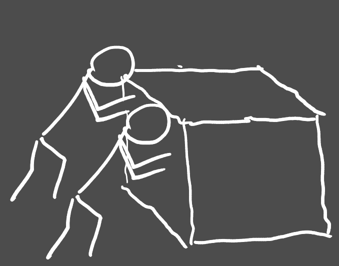
long-range
* gravitational force - force between any objects that have the property of mass
* electromagnetic force - force between any objects that have the property of charge

* weak force
* strong force

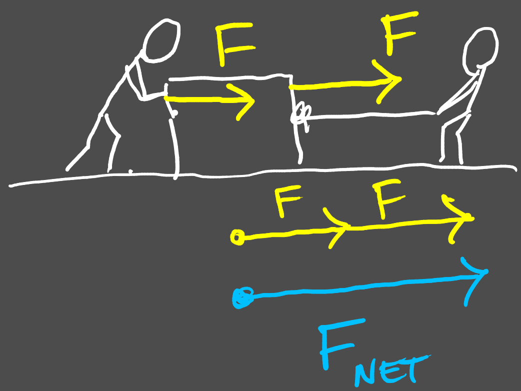
very short range

weight

What about multiple forces?

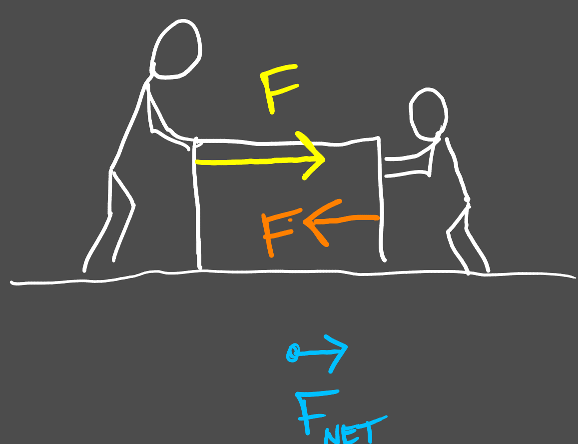


2 standard push work together to double the force.



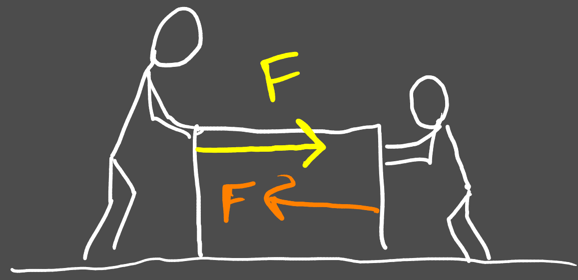
2 push act together in way that is indistinguishable from a single **net force**

→ effective force

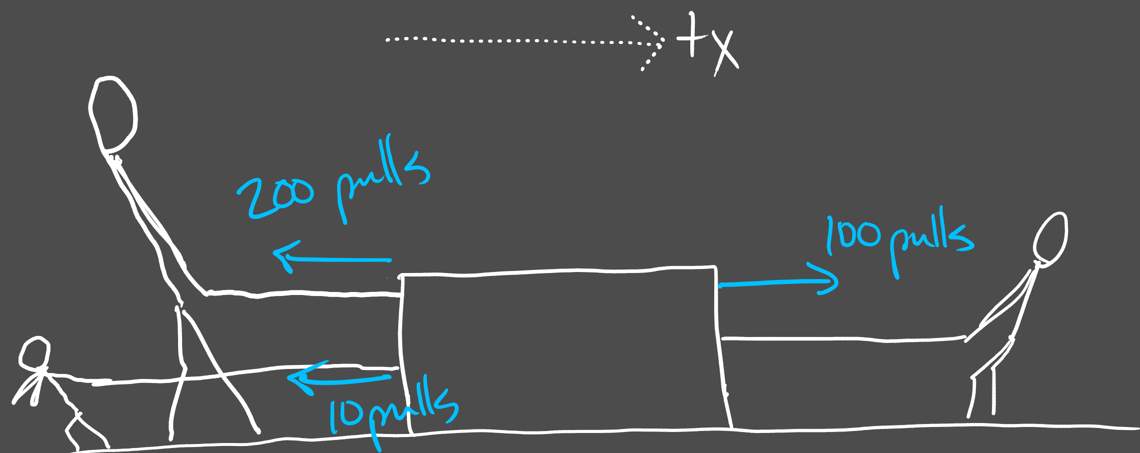


forces in opposing directions work to diminish the **net force**

Adding forces up to find the net force.



$F_{NET} = 0$



$F_{NET} = +100 + (-200) + (-10)$

$F_{NET} = -110$ pulls

Newton's Laws

Newton's 1st Law - what happens when no net force acts
* if the object is not moving, it continues to not move
* if the object is moving, it continues to move in the same direction at the same speed (constant velocity)

if $a=0$
then no net force

Newton's 2nd Law - law of motion
* net force causes acceleration
* net force = mass * acceleration

$$F_{NET} = m \cdot a$$

Newton's 3rd - law of interaction
* forces always occur in pairs
* every action has an equal and opposite reaction

careful

LAB | Measuring forces – we want to reliably measure a push/pull

units 1 standard push = 1 ~~Remington~~

= 1 Newton

$$F_{NET} = m \cdot a$$

$$[kg]\left[\frac{m}{s^2}\right] = 1\,\frac{kg\,m}{s^2} = 1 \text{ Newton}$$

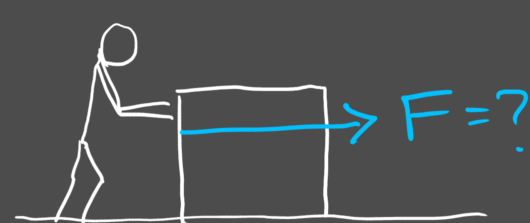
→ 1st way – measure the force's effect

$$m,\ \Delta v,\ t \rightarrow \underline{\underline{F_{NET}}}$$

→ 2nd way – compare all push/pulls to force of gravity

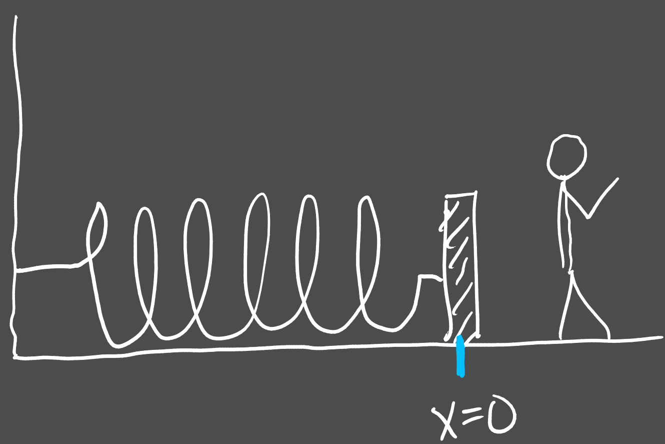
$$F_g = m \cdot 9.8\,m/s^2$$

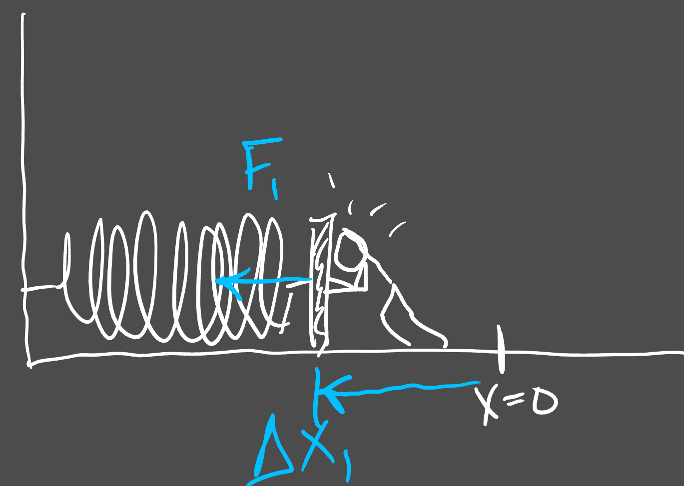
– consistent amounts of mass cause consistent force



→ 3rd way → use a spring!

- portable
- reliable
- need to calibrate

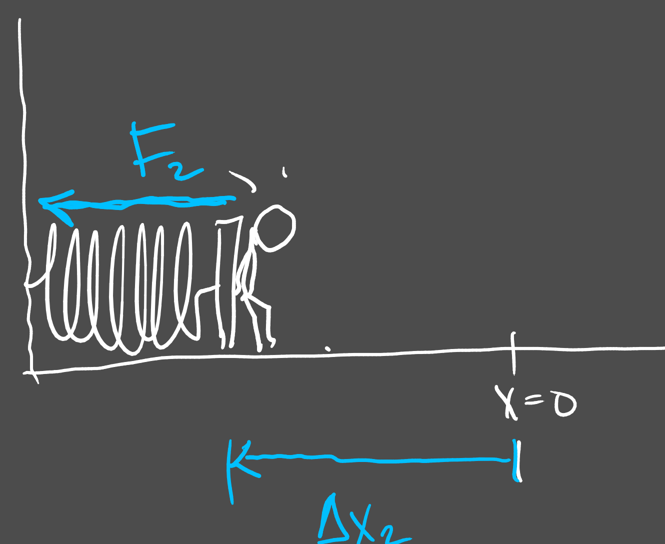




$$\frac{F_1}{\Delta x_1} = \frac{F_2}{\Delta x} = k$$

spring constant

measure of stiffness



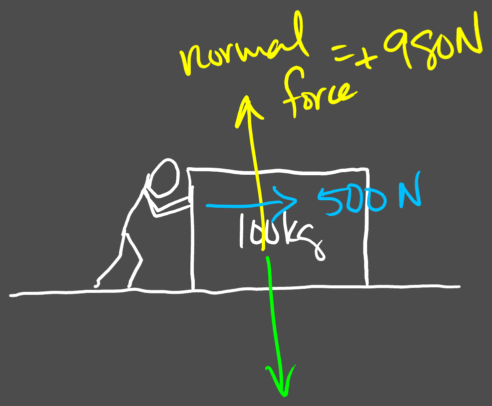
Examples:

Newton's $2^{nd} \rightarrow F_{NET} = ma$

$\hookrightarrow a = \frac{F}{m}$

$a = \frac{500N}{100kg}$

$a = 5\,m/s^2$



$F_g = m \cdot g$

$F_g = 100kg \cdot 9.8\,m/s$

$F_g = 980N$

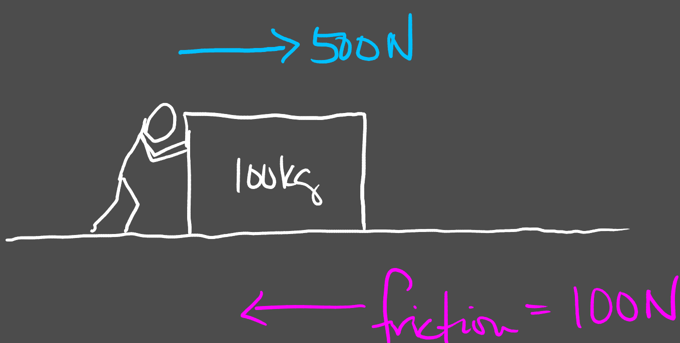
$F_g = -980N$

$\boxed{F_{NET}} \rightarrow$ sum of the individual forces

$\hookrightarrow$ seperat net force for vertical and horizontal motion

$\hookrightarrow$ we observe no vertical motion, so Newton's 1st tells us the F_{NET} in that direction is zero

$\longrightarrow +x$



$F_{NET} = +500N + (-100N)$

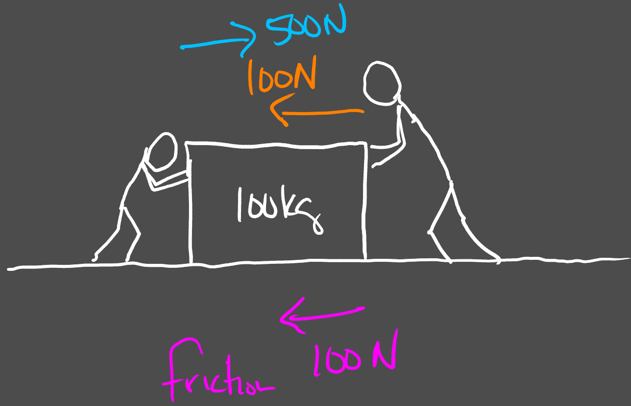
$= +400N$

$F_{NET} = ma$

$400N = 100kg \cdot a$

$\downarrow$

$a = 4\,m/s^2$



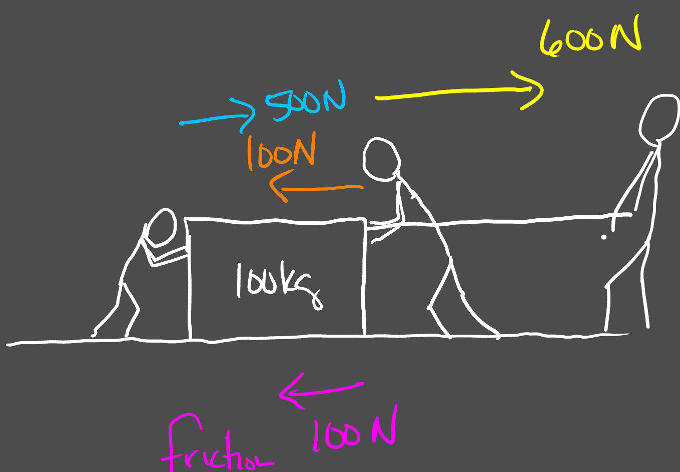
$$F_{NET} = +500N + (-100N) + (-100N)$$

$$= 300N$$

$$F_{NET} = m \cdot a$$

$$300N = 100k \cdot a$$

$$a = 3 m/s$$



$$F_{NET} = 500N - 100N - 100 + 600N$$

$$= 900N$$

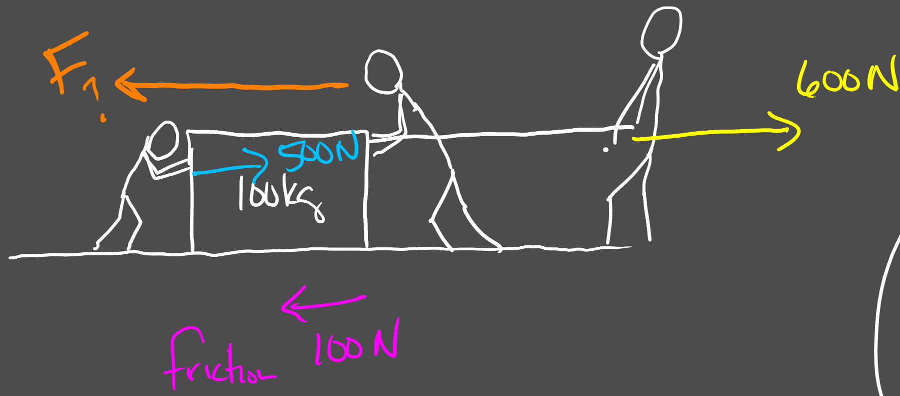
$$900N = 100kg \cdot a$$

$$a = +9 \ m/s^2$$

$$F_{NET} = 0 = \underbrace{500N - 100N + 600N}\; + F_?$$

$$0 = 1000N + F_?$$

$$\boxed{-1000N = F_?}$$



$$F_{NET} = 0, \quad a \overset{!}{=} 0$$

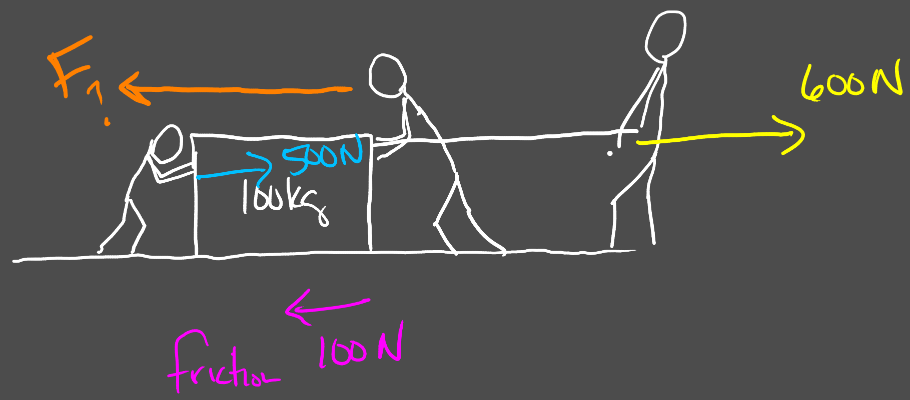
Can the object be in motion? YES!

it can have a constant velocity

Can the object be at rest? YES!

(motionless)

0 m/s is still a constant velocity



$$a = 7\,m/s^2$$

$$F_{NET} = m \cdot a$$

$$F_{NET} = 100kg \cdot 7\,m/s^2$$

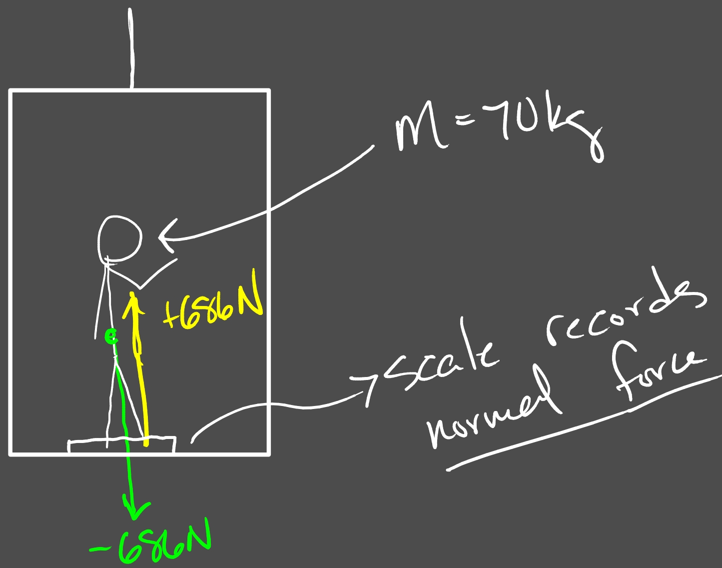
$$F_{NET} = 700N$$

$$700N = \underbrace{500N + 600N - 100N}_{1000N} + F_?$$

$$700N = 1000N + F_?$$

$$-300N = F_?$$

Vertical Forces/Motion:



#1 | elevator is motionless

weight: $-686N = m \cdot g = 70kg \cdot 9.8 m/s^2$

normal: 686N ← b/c elevator is not moving

#2 | elevator is going up at constant speed:

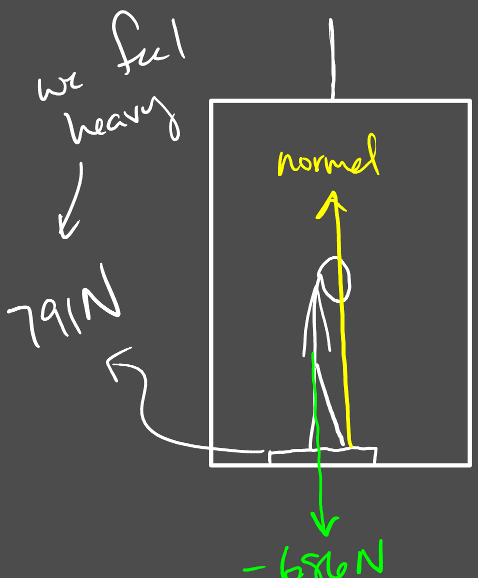
weight: $-686N$

normal: 686N

#3 | elevator is accelerating upward $+1.5\ m/s^2$

weight: $-686N$

normal:



$F_{NET} = 70kg \cdot 1.5 m/s^2$

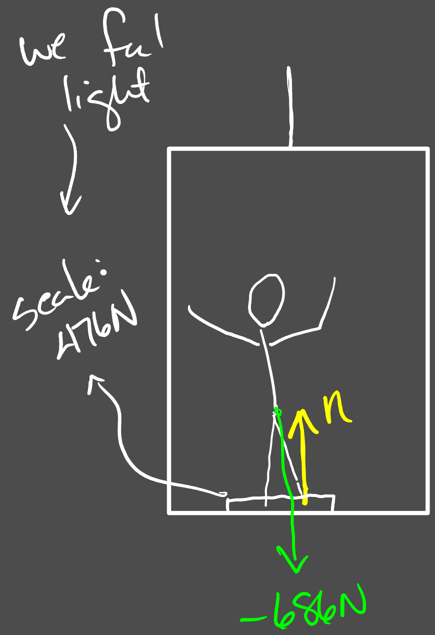
$F_{NET} = 105\ N$

normal + weight $= F_{NET}$

normal $+ (-686N) = 105N$

$n = 105N + 686N$

$\boxed{n = 791N}$



$$F_{NET} = 70\,kg \cdot (-3\,m/s^2)$$

$$F_{NET} = -210\,N$$

$$-210\,N = \text{normal} + \text{weight}$$

$$\underset{+686}{-210\,N} = n + (\cancel{-686\,N})\underset{+686}{}$$

$$n = +476\,N$$

#4] acceleration is downward

$-3\,m/s^2$.

weight: $-686\,N$

normal: $+476\,N$