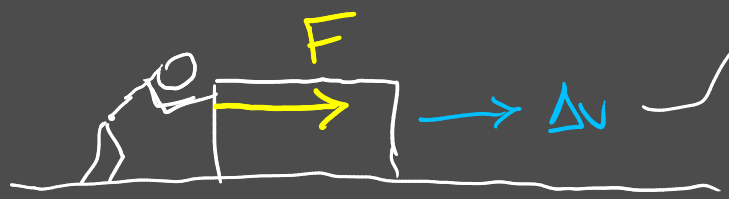
Forces - the cause of change in motion

- 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

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

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

$$\frac{m \cdot \Delta v}{\Delta t} = \frac{F \cdot \Delta t}{\Delta t}$$ ← 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 = weight = mass [kg] × 9.8 m/s^2 g

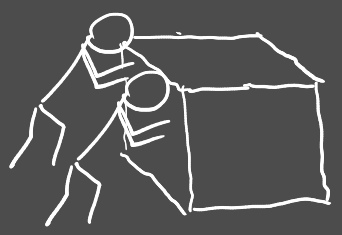
Non-contact forces

Fundamental Forces:

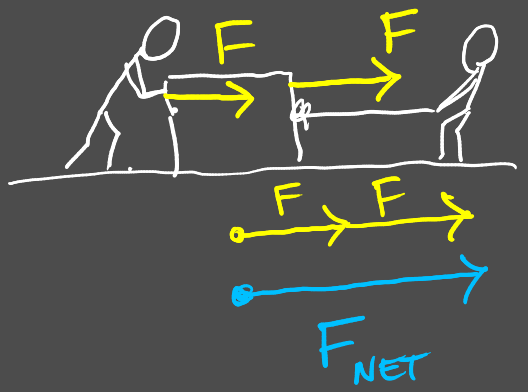
long-range
* gravitational force - force between any objects that have the property of mass → weight
* electromagnetic force - force between any objects that have the property of charge

very short range
* weak force
* strong force

What about multiple forces?

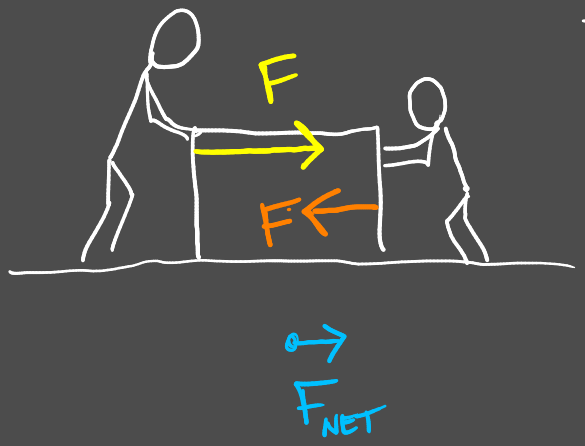


2 standard push work together to double the force.



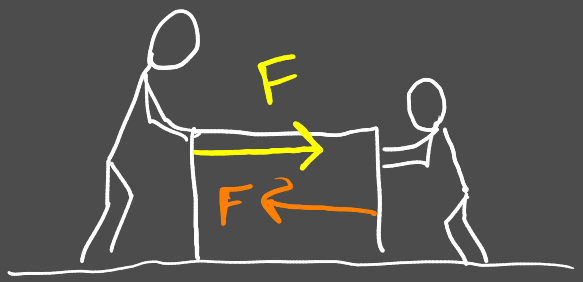
2 push act together in way that is indistinguishable from a single net force

→ effective force

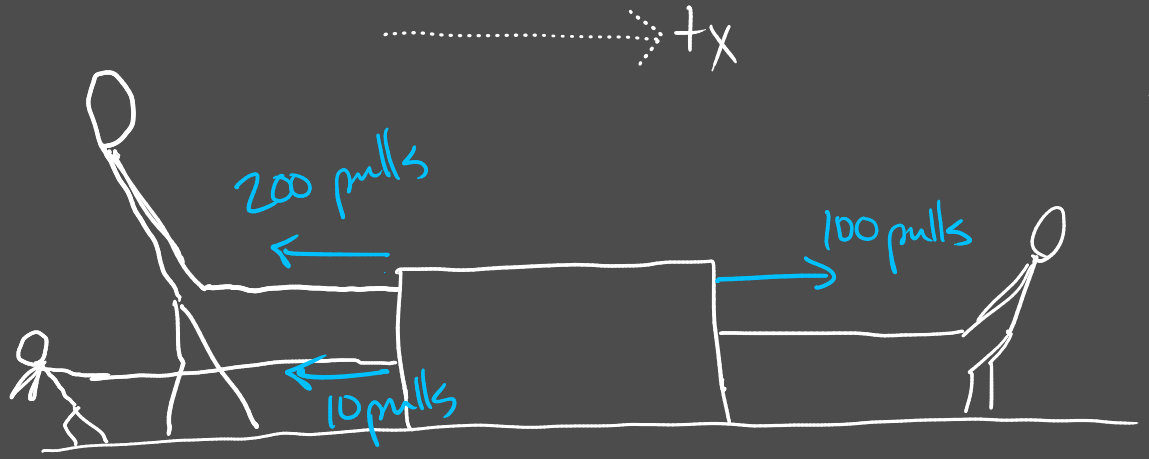


forces in opposing directions work to diminish the net force

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

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

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

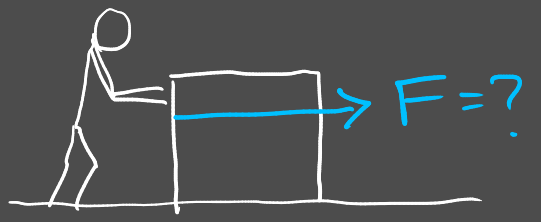
→ 1st way - measure the force's effect

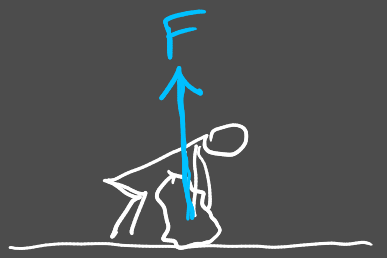
$$m, \Delta v, t \rightarrow F_{NET}$$

→ 2nd way - Compare all push/pulls to force of gravity

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

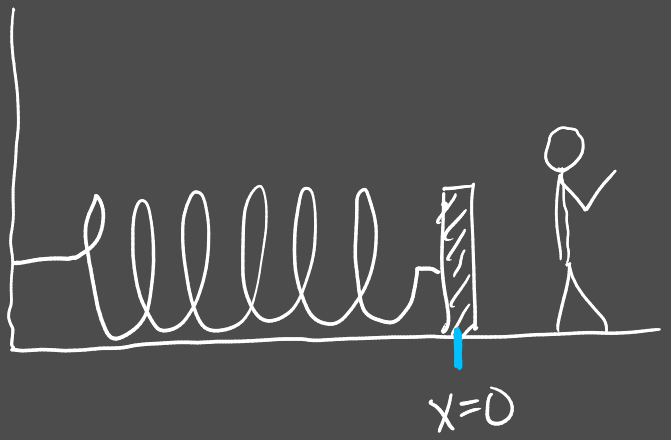
- Consistent amounts of mass cause consistent force

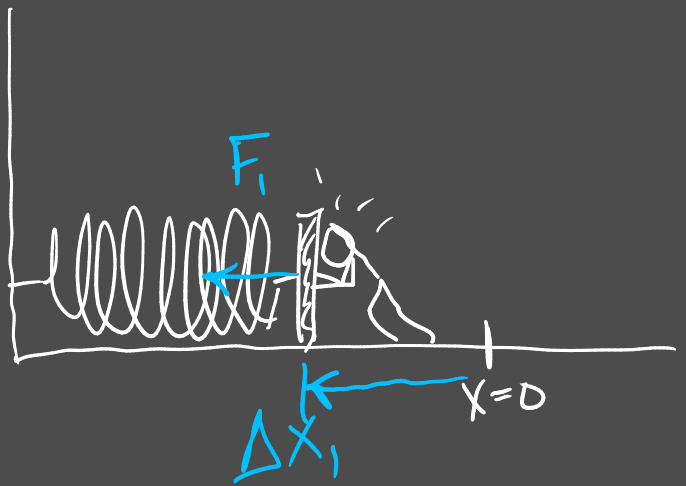




→ 3rd way → use a spring!

- portable
- reliable
- need to calibrate





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

spring constant

measure of stiffness