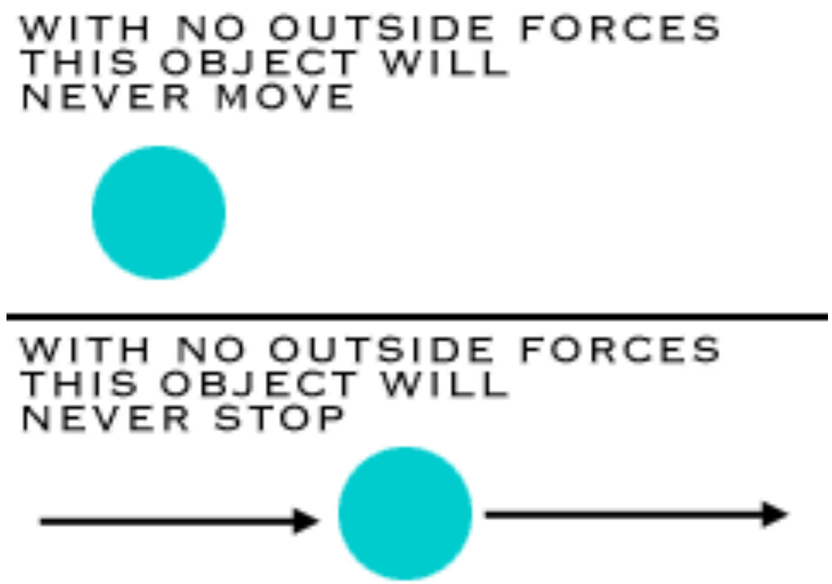
College Physics I: 1511 Mechanics & Thermodynamics

Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Newton's First Law

- An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.



Definition: Force (Newton's 2nd Law)

$$\vec{F} = m\vec{a}$$

Concept Check

- A constant force is exerted for a short time on a cart (initially at rest) on an air track. This force gives the cart a certain final speed. The same force is exerted for the same length of time on another cart, also initially at rest, that has twice the mass of the first one. The final speed of the heavier cart is

- A: one-fourth
- B: four times
- C: half
- D: double
- E: the same as

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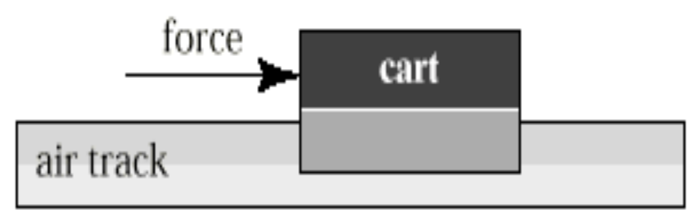


Force on carts

$$a = \Delta v / \Delta t$$

$$\Rightarrow \Delta V = a \, \Delta t$$

but $F = ma$

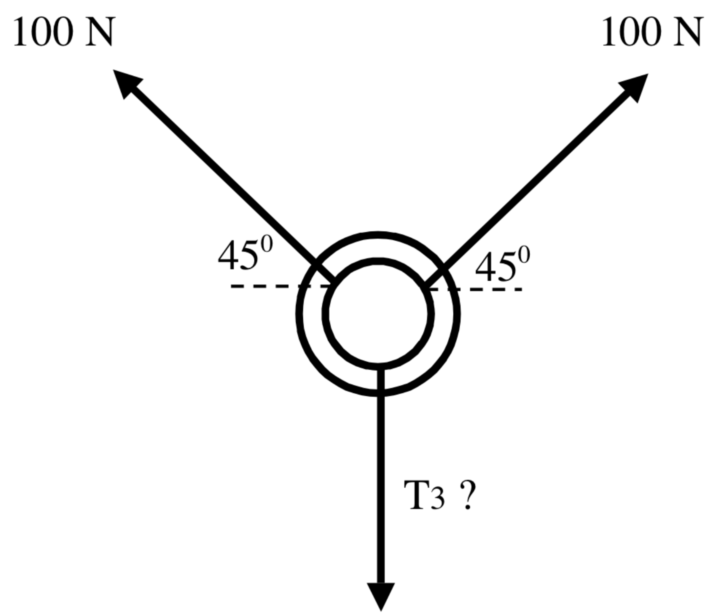
$$\Rightarrow a = F/m$$

so $\Delta V = F/m \, \Delta t$

$$\frac{\Delta V_2}{\Delta V_1} = \frac{F/m_2 \, \Delta t}{F/m_1 \, \Delta t} = \frac{m_1}{m_2} = 1/2$$

Concept Check

Three people are pulling on a ring in a "2-D" tug of war. Shown is a "top view".



No one is winning - the ring is sitting still.

The pulls are configured as shown (teams 1 and 2 are each pulling with a force of 100 N.
Team 3 pulls with unknown force T3)

How hard is team 3 pulling?

A) 100 N **B)** 200 N **C)** 141 N **D)** 71 N **E)** 0 N

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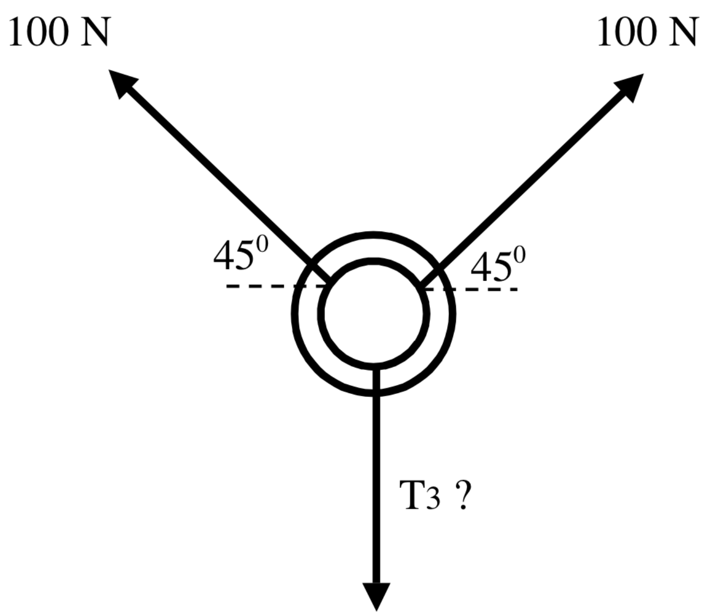

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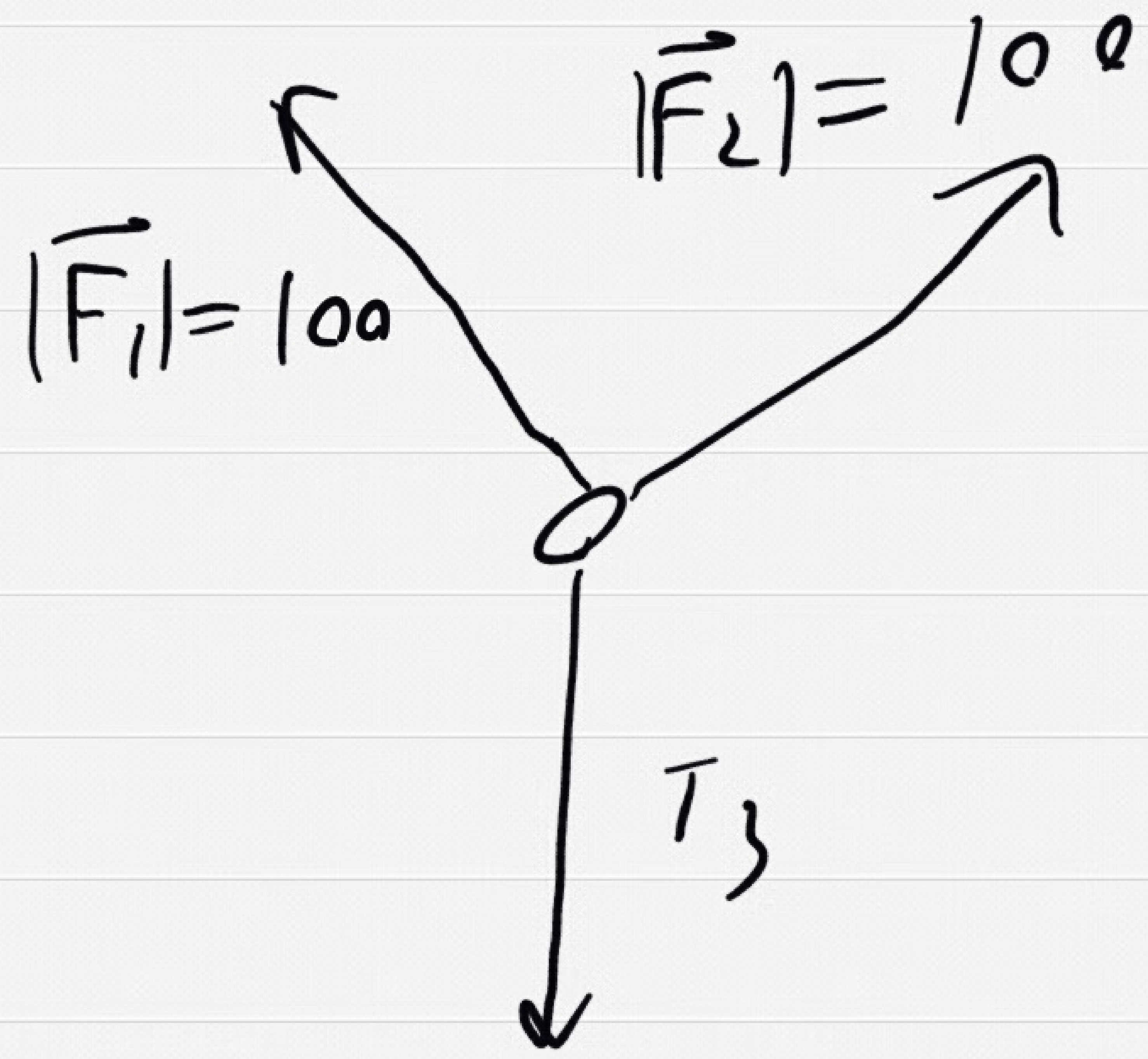
Ring pull



x − component

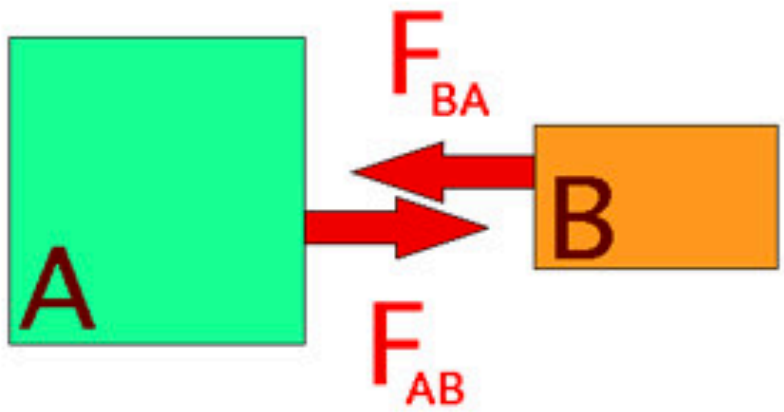
$$F_{x\,net} = F_{1x} + F_{2x}$$
$$= -100 \cos 45^\circ + 100 \cos 45^\circ$$
$$= 0$$

$$F_{y\,net} = F_{1y} + F_{2y} - T_3$$
$$= 100 \sin 45^\circ + 100 \sin 45^\circ - T_3$$
$$= 200 \sin 45^\circ - T_3$$
$$= 141 - T_3$$
$$= 0$$

$$\Rightarrow T_3 = 141$$

Newton's Third Law

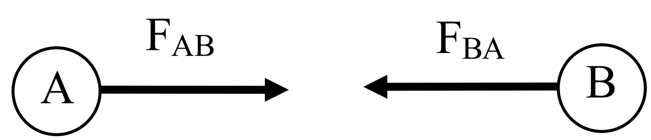
- Newton's Third Law of Motion
  - When one object exerts a force on a second object, the second object exerts an equal but opposite force on the first.



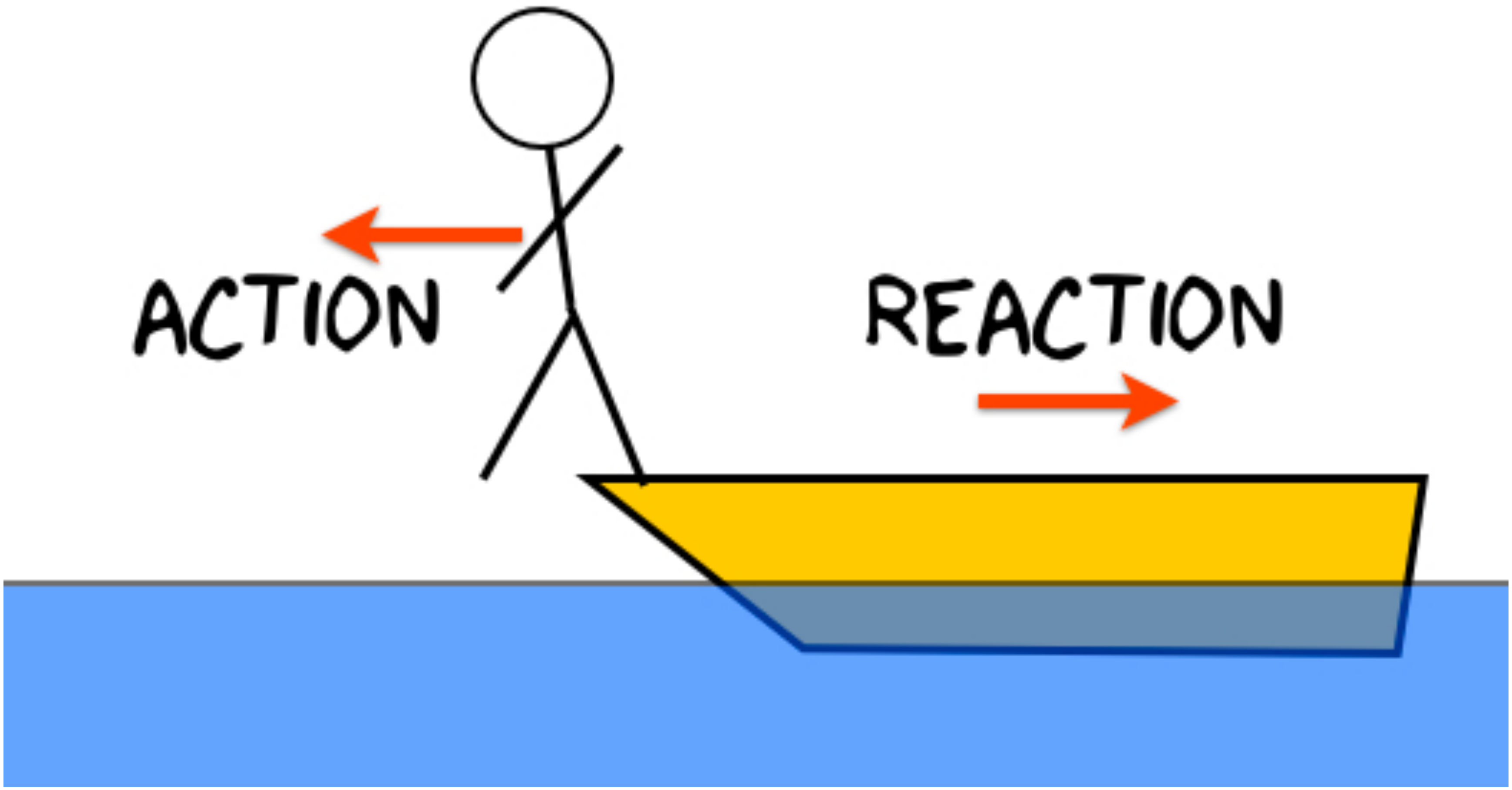
Newton's Third Law

- Newton's Third Law (NIII): If body A exerts a force on body B ($= \vec{F}_{BA} = \vec{F}_{\text{on B by A}}$), then B exerts an equal and opposite force on A ($= \vec{F}_{AB} = \vec{F}_{\text{on A by B}}$).

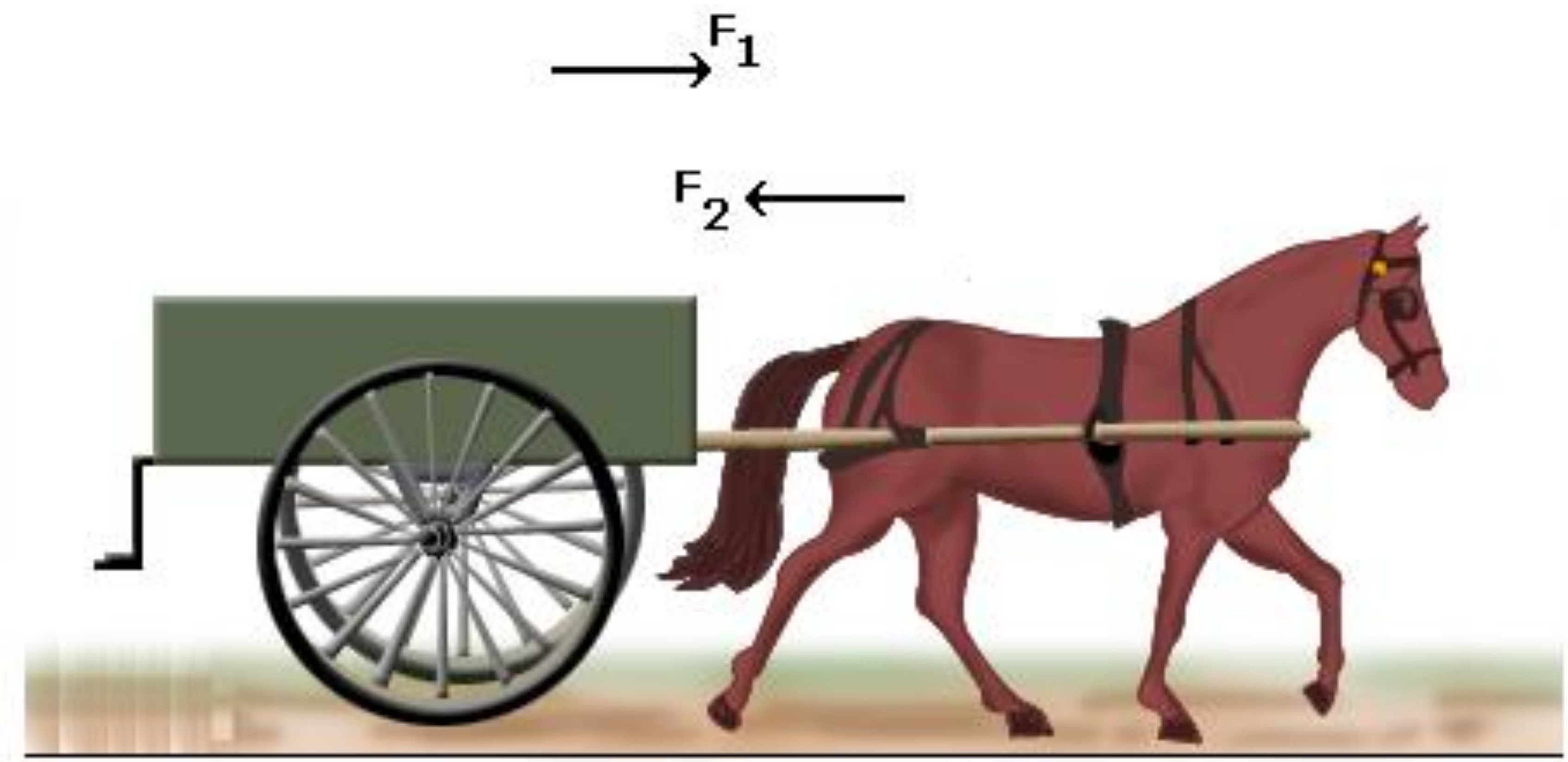
$$\underbrace{\vec{F}_{BA} = -\vec{F}_{AB}}_{\text{2 forces on 2 different objects}}$$



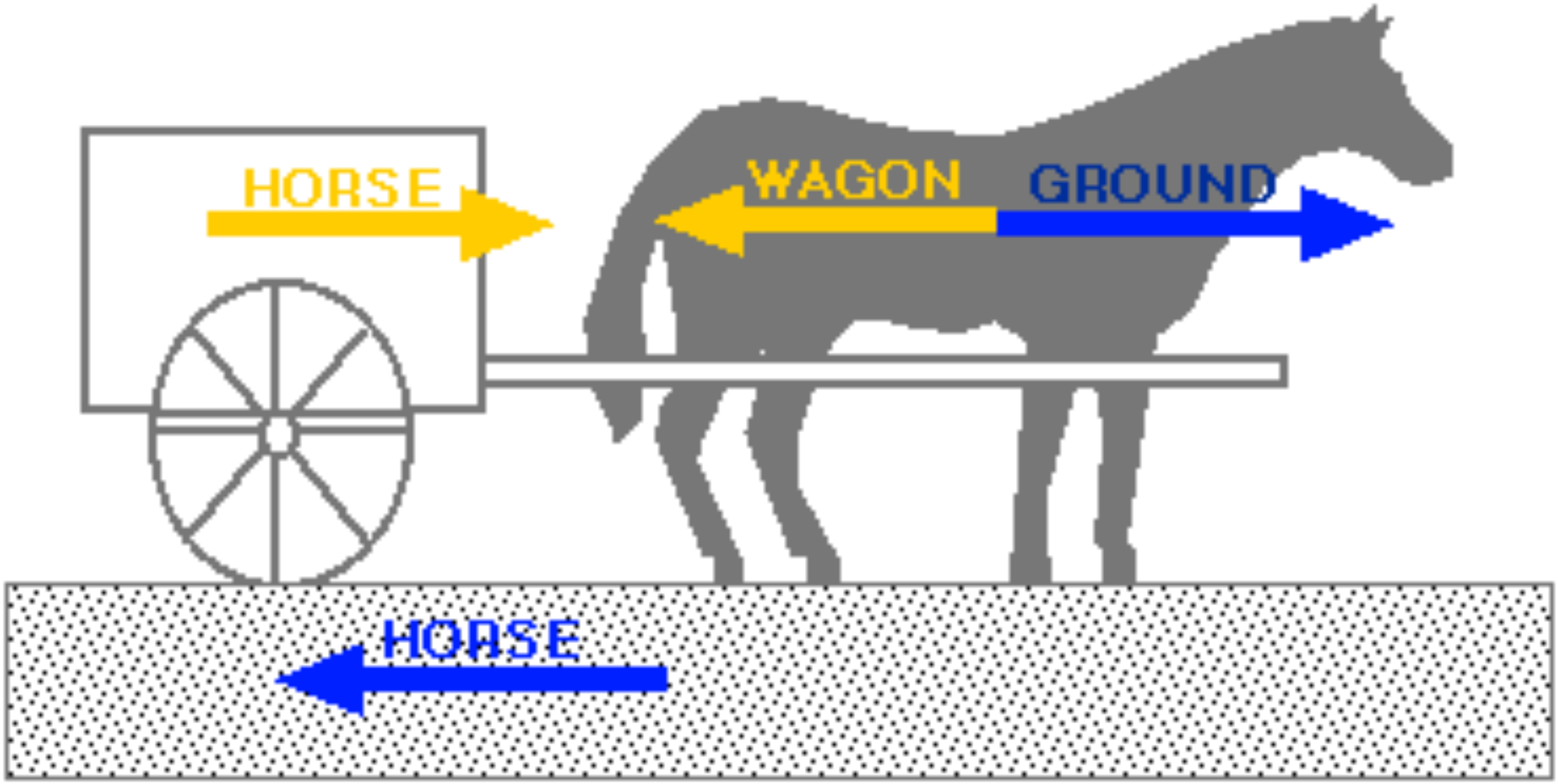
Action-Reaction



Horse and Cart

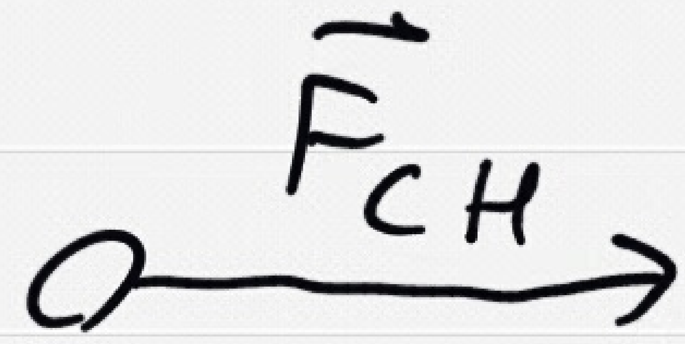


Horse and Cart Analysis

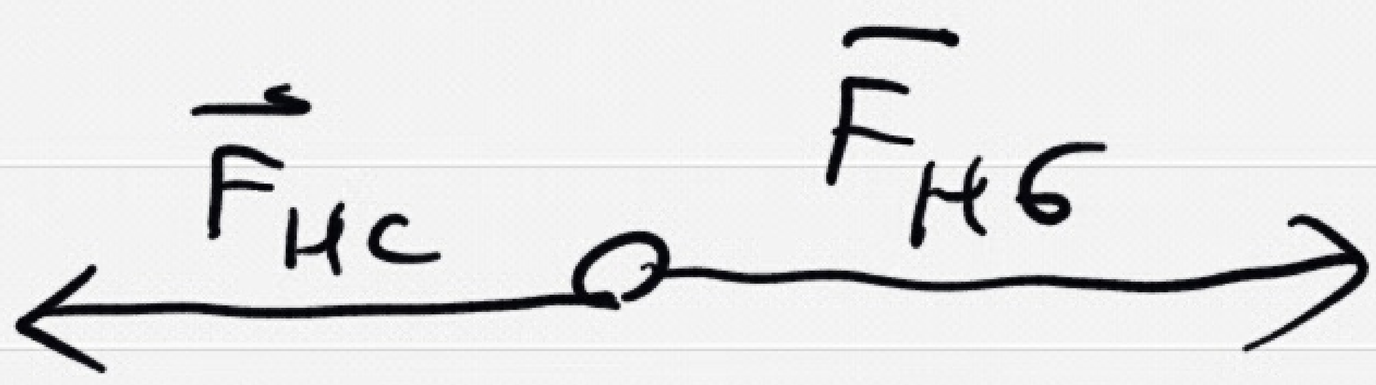


Horse and Cart

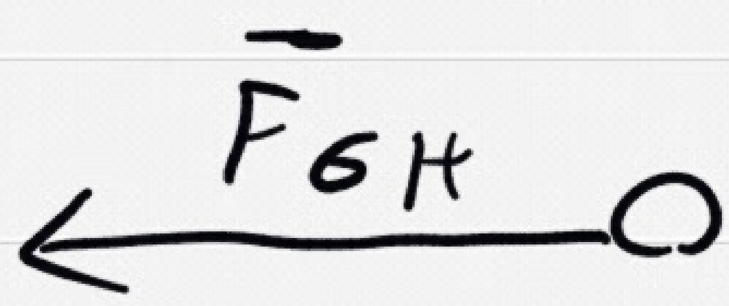
Cart



Horse



Ground



$$\vec{F}_{CH} = -\vec{F}_{HC}$$

$$\vec{F}_{HG} = -\vec{F}_{GH}$$

Total force on cart $\vec{F}_{CH}$

Total force on horse $\vec{F}_{HG} + \vec{F}_{HC}$

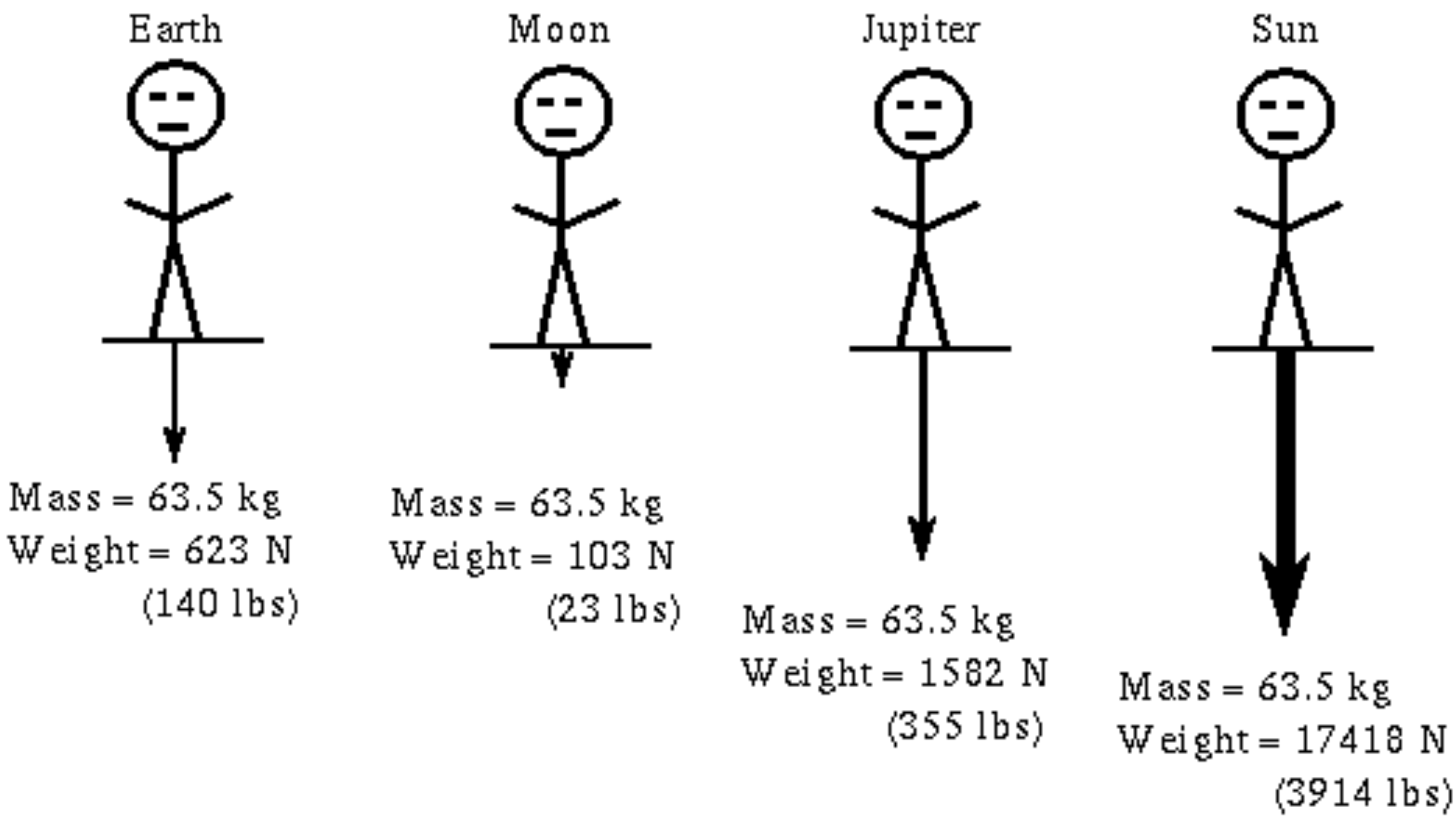
Gravitational Force

- On Earth
  - $F_G = mg = W$ (weight)
  - More generally, $F_G = Gm_1m_2/r^2$
    - (don't need to know this equation)
  - $g = GM_E/R_E^2$ (E stands for Earth!)

Mass Vs. Weight

Mass	Weight
• is measured in kilograms	• is measured in Newtons
• always remains the same	• can change with location
• is closely related to inertia	• is closely related to gravity
• can NOT be measured directly	• can be measured directly using a scale

Mass Vs. Weight



Concept Check

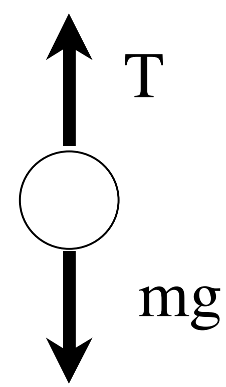
A scale estimates an object's weight by measuring the tension on a spring. There are two forces on the object, the weight (magnitude mg) and the tension, magnitude T, in the cord. For a stationary object, these balance, so a measure of T is equivalent to a measure of weight. What if you pull up hard on the object, accelerating it upward. How will the apparent weight W_{app} you register on the scale compare to the weight mg you registered when stationary?

Which equation is true:

A: $W_{app} = mg$

B: $W_{app} > mg$

C: $W_{app} < mg$



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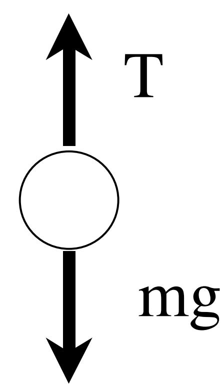
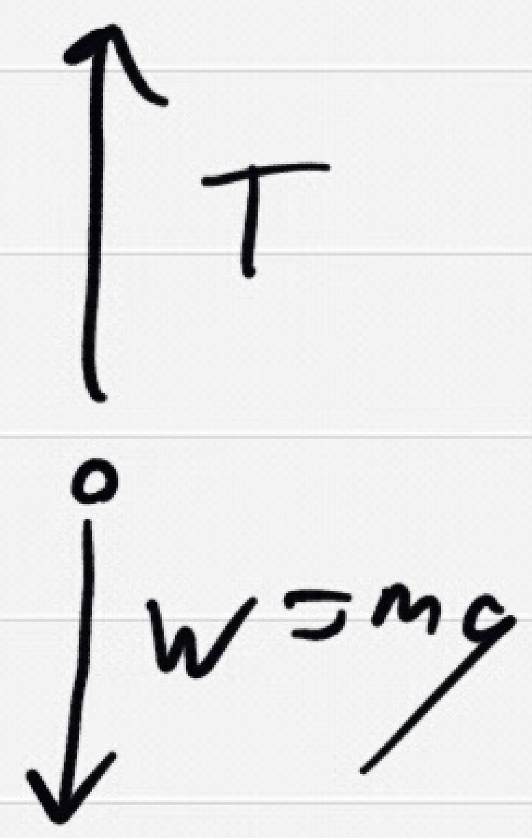


Weight on scale

scale

weight



Force upward on weight

$= F_{net} = T - mg$

$= 0$ if $a = 0$

if $F_{net} > 0$

then $T - mg > 0$

or $T > mg$

$ma = T - mg \Rightarrow T = ma + mg$

apparent weight $W_{app} = ma + mg$