Classical Mechanics
Lecture 3

Today's Concepts: *Newton's Laws*

a) Acceleration is caused by forces

b) Force changes momentum

c) Forces always come in pairs

d) Good reference frames

Stuff you asked about:

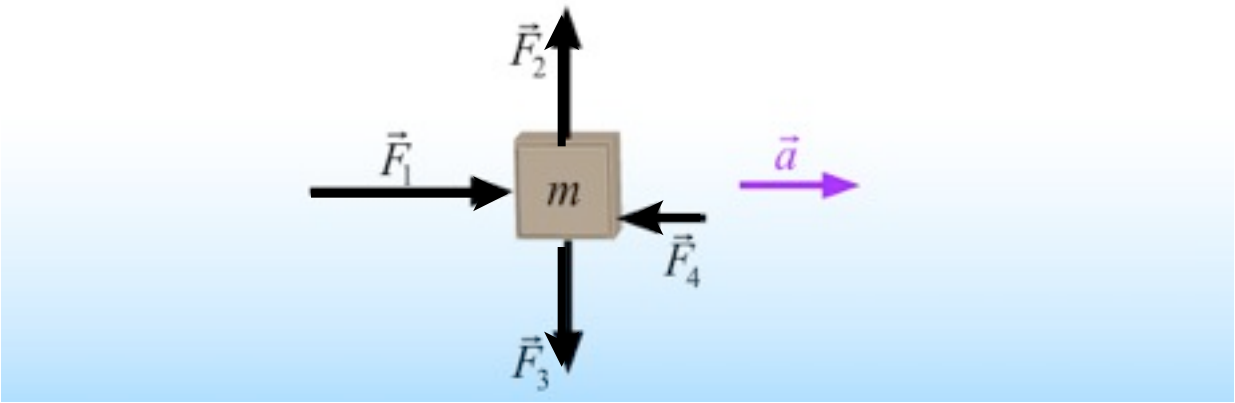
- im thinkin there is nothin to worry about for this business. its not a situation.
- In the prelecture everything seems pretty straight forward, but when the checkpoint came it was more blurry. I read the textbook, but it as no mention of momentum. Looking forward to the class to have a deeper understanding, the prelecture does not explain much.
- Getting momentum from the equation F=ma
- I knew all of these surprisingly well. Or at least I think I do.
- can you pleae please please please please do some problems in the class like what we are going to get in midterms and finals !!! physics needs to be applied in order to understand it ! please and thank you <3 [here :]
- How does net force differ from other forces? Also, in relation to centripetal motion, in which directions are acceleration, momentum, and velocity.
- why the acceleration of the car is towards the center of the circle, yet the car's velocity is pointing directly forward from the car at any point in time.
- i feel good about Newton's law
- i love newton!!!! forces are so much fun

Newton's 2nd Law

$$\vec{a} = \frac{\vec{F}_{Net}}{m}$$

where

$$\vec{F}_{Net} \equiv \sum_{i=1}^{N} \vec{F}_i = \vec{F}_1 + \vec{F}_2 + \ldots + \vec{F}_N$$



Acceleration is caused by force.

A bigger mass makes this harder

CheckPoint

The net force on a box is in the positive x direction.

Which of the following statements best describes the motion of the box :

A) Its velocity is parallel to the x axis

B) Its acceleration parallel to the x axis

C) Both its velocity and its acceleration are parallel to the x axis

D) Neither its velocity or its acceleration need be parallel to the x axis

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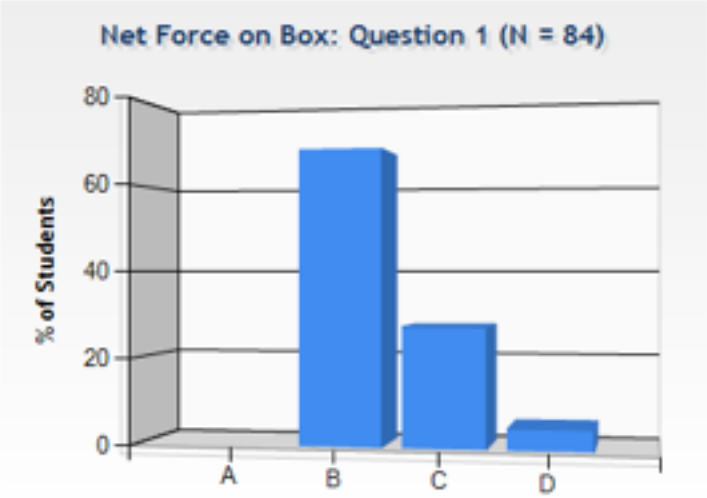
D) Neither its velocity or its acceleration need be parallel to the x axis

B) F = ma so force in the x direction will cause an acceleration in that direction but the velocity is not stated so it may have a y velocity and/or a negative starting x velocity.

C) The direction of acceleration is the same as the direction of the force. And the direction of velocity is the same as that of acceleration.



Concerns you raised:

- I did not clearly understand the relation between force and momentum and I hope we go over it in class.
- when to take into consideration two forces acting on an object or when to only take into account one force.

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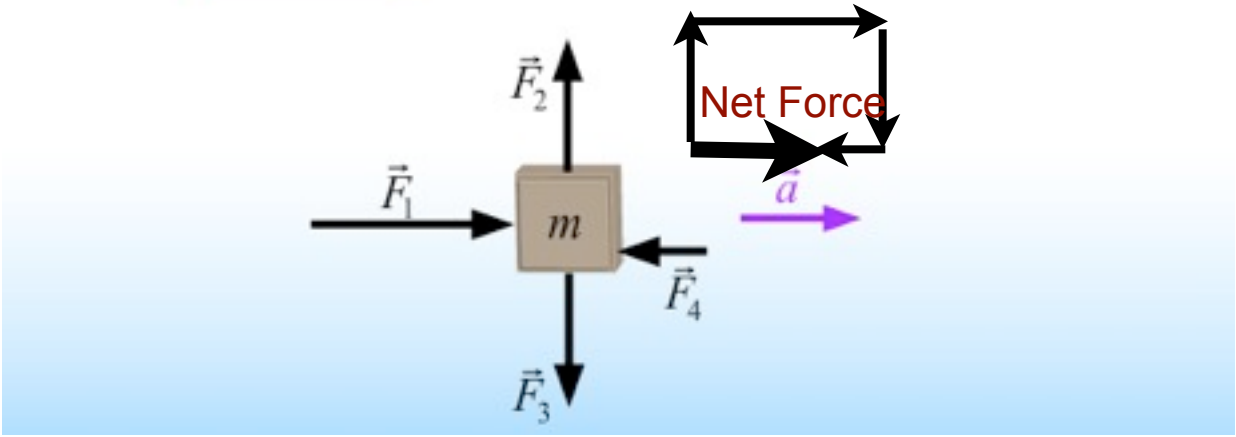


Acceleration is caused by force.

A bigger mass makes this harder

more Concerns you raised:

- The bug getting smashed by the car concept.
  - Later we will smash carts together and measure the forces.
- Can we go over the example given in the pre-lecture, where they express that according to Newton's third law, only the force that the man is exerting on the box is taken into account and not the force back on the man?
  - Try a demo with two ppl on chairs pushing off each other.

Clicker Question

A force F is applied to a small block, that pushes a larger block. The two blocks accelerate to the right. Compare the NET FORCE on the block with mass M, to the net force on the block with mass $5M$.

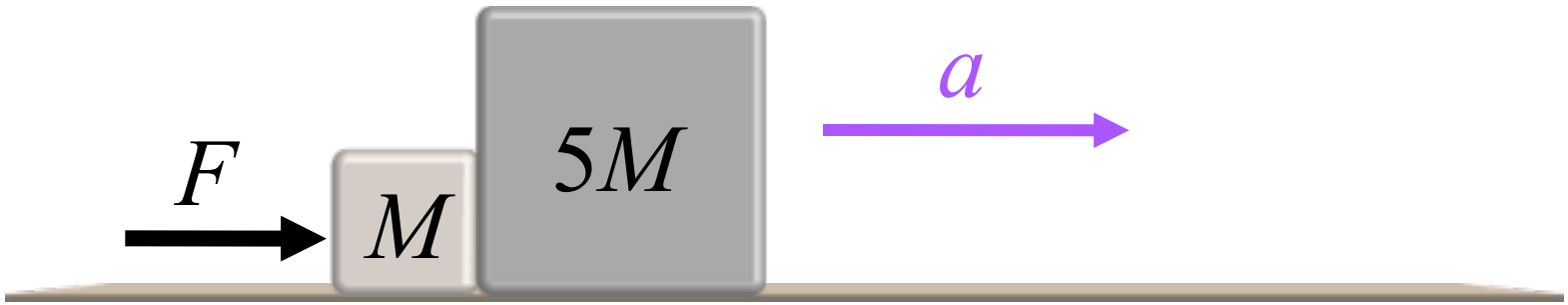
$$\underbrace{\sum \vec{F}}_{\text{Net Force}} = m\vec{a}$$

A) $F_M < F_{5M}$

B) $F_M = F_{5M}$

C) $F_M > F_{5M}$

Same acceleration, so larger mass has larger net force.



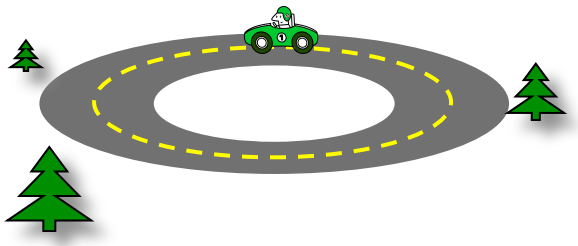
Aside: Centripetal acceleration and force

1) Objects moving in a circle always have a component of acceleration, called centripetal, which is toward the center of the circle.*

2) Centripetal acceleration must be caused by a force:
   - Friction, gravity – whatever force keeps it moving in a circle.
   - This force is often called the "centripetal force"

3) There is no "new" kind of force here.

4) There is no such thing as centrifugal force.



* They can have also have tangential acceleration if their speed is not constant

Momentum & Force

Momentum

$$\vec{p} \equiv m\vec{v}$$

Newton's 2nd Law

$$\vec{F}_{Net} = \frac{d\vec{p}}{dt}$$

Two Conclusions:

1. If $\vec{F}_{Net} = 0$, then $\frac{d\vec{p}}{dt} = 0 \longrightarrow \vec{p}$ is constant

2. $d\vec{p} = \vec{F}\,dt$

Students' Momentum Concerns

- Need more feedback on the topic of momentum
- The concept of momentum was very confusing to me.
- Concept of momentum is bit confusing..

$$\vec{p} = m\vec{v}$$

Oooomf

CheckPoint

You are driving a car with constant speed around a horizontal circular track. The momentum of your car

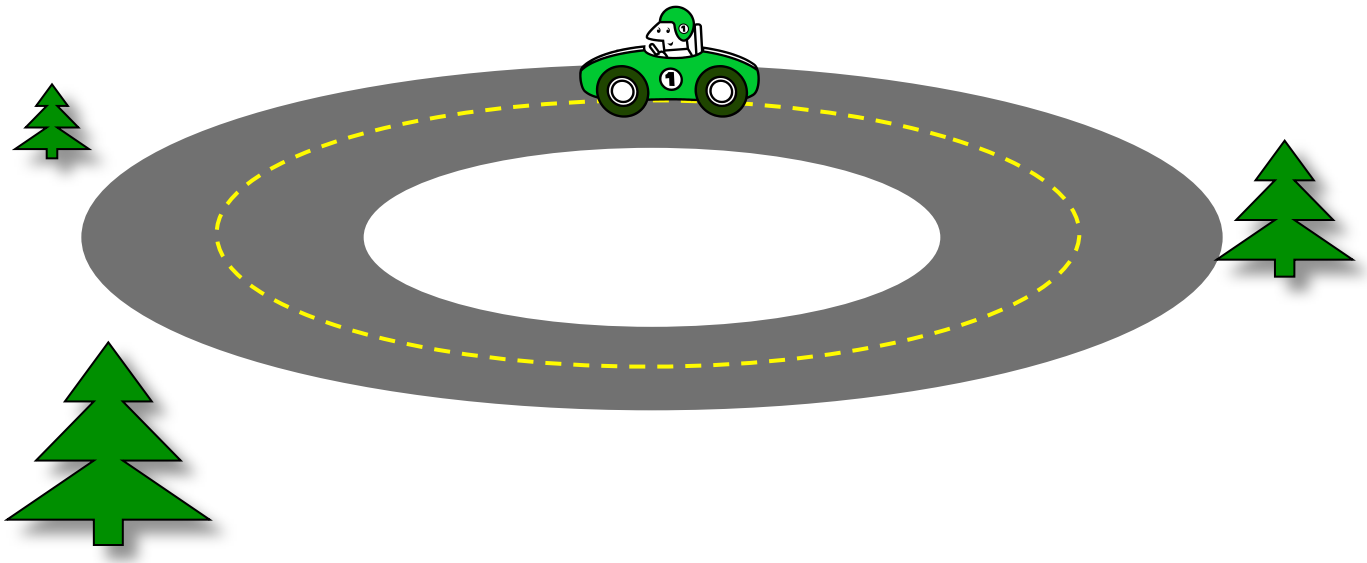
A) Points radically inward toward the center of the circular track

B) Points radically outward, away from the center of the circular track

C) Points forward in the same direction your car is moving

D) Points backward, opposite to the direction your car is moving

E) Is zero.



CheckPoint Responses

You are driving a car with constant speed around a horizontal circular track. The momentum of your car

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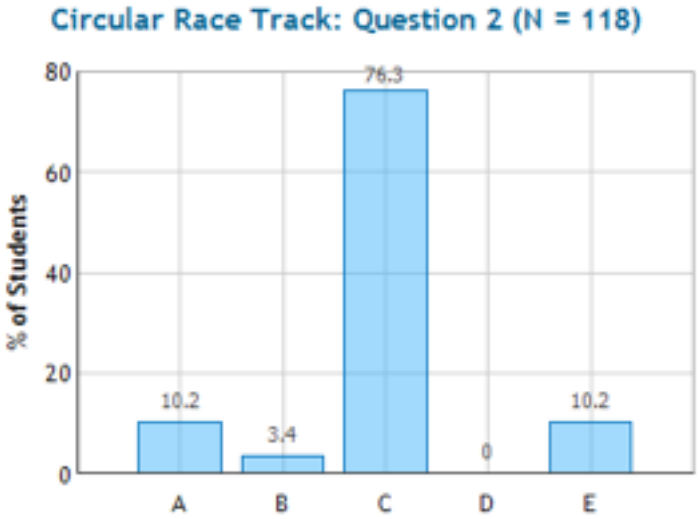
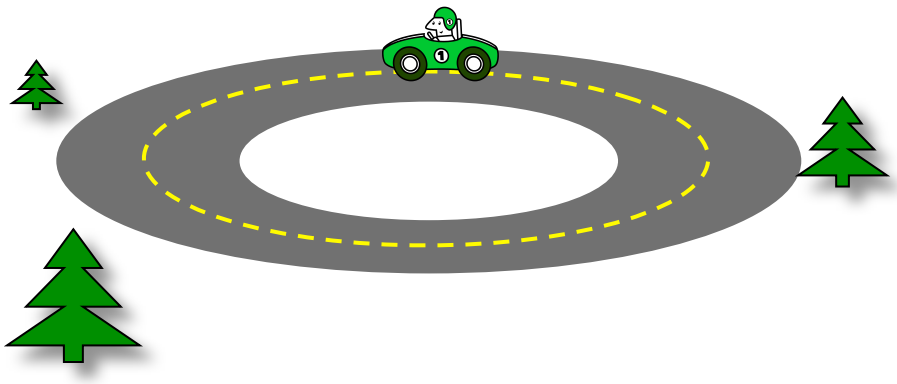
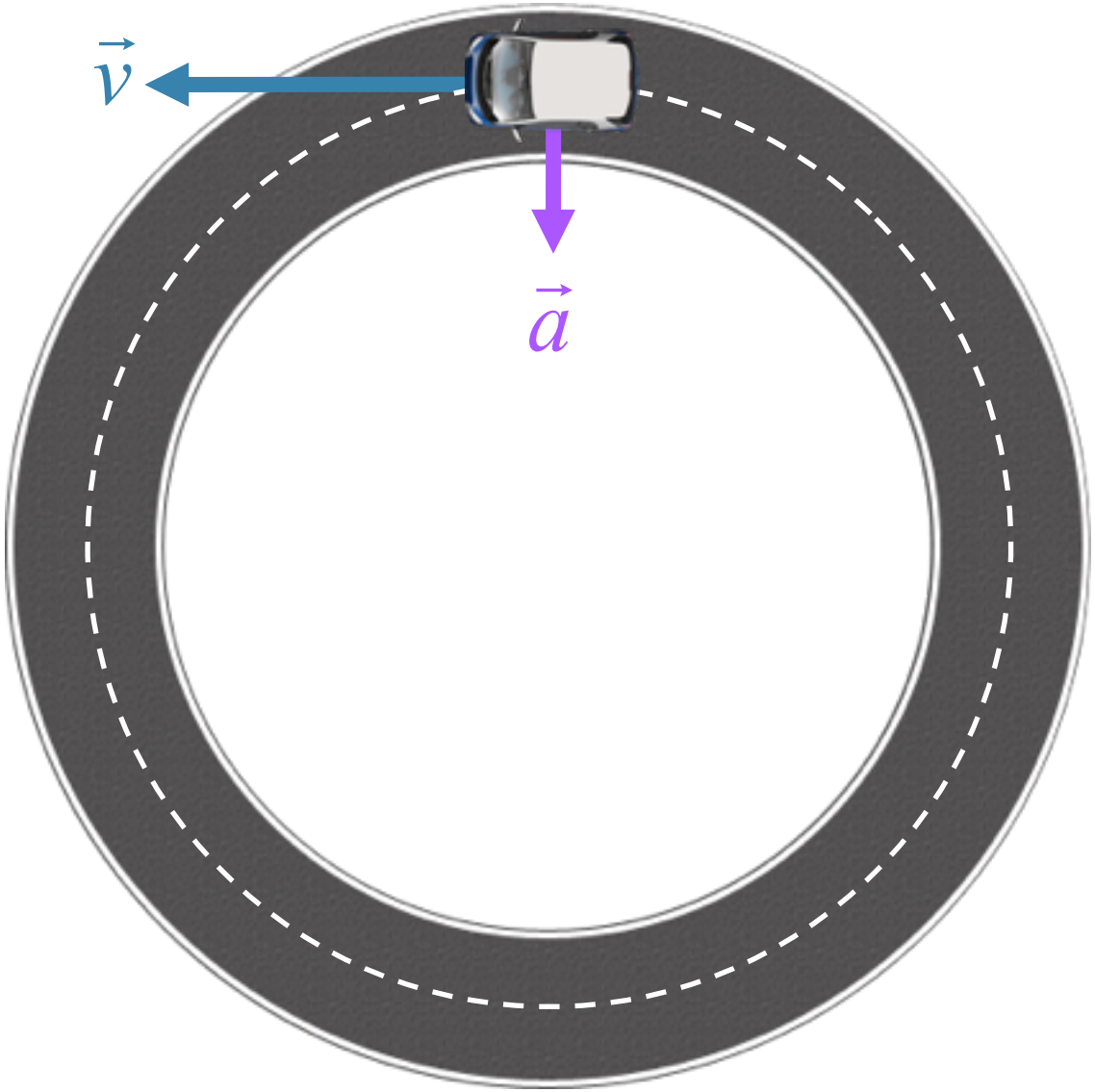
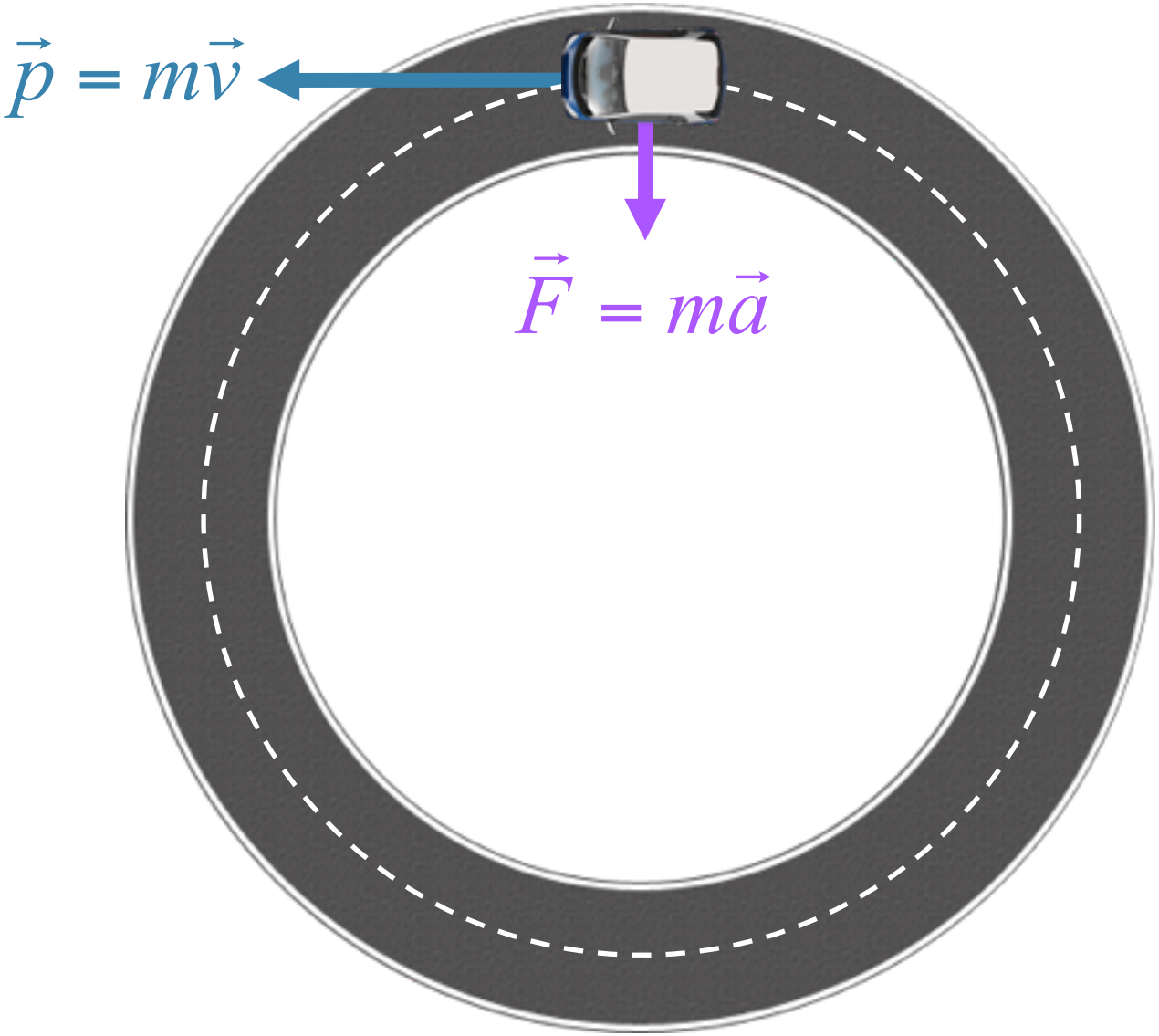




A) The momentum is in the same direction as the force.

C) It points in the same direction as v, which is forward


$\vec{v}$
$\vec{a}$


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

Newton's 1st Law

An object subject to no external forces is at rest or moves with constant velocity if viewed from an inertial reference frame.

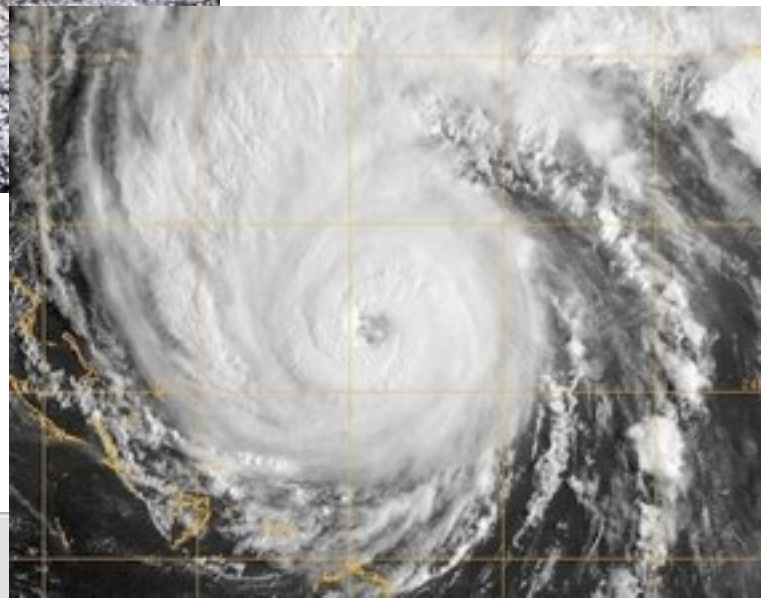
Inertial Reference Frame ≡ Reference Frame in which Newton's Laws are valid

Ice-puck

Fake Forces: Coriolis (YouTube)

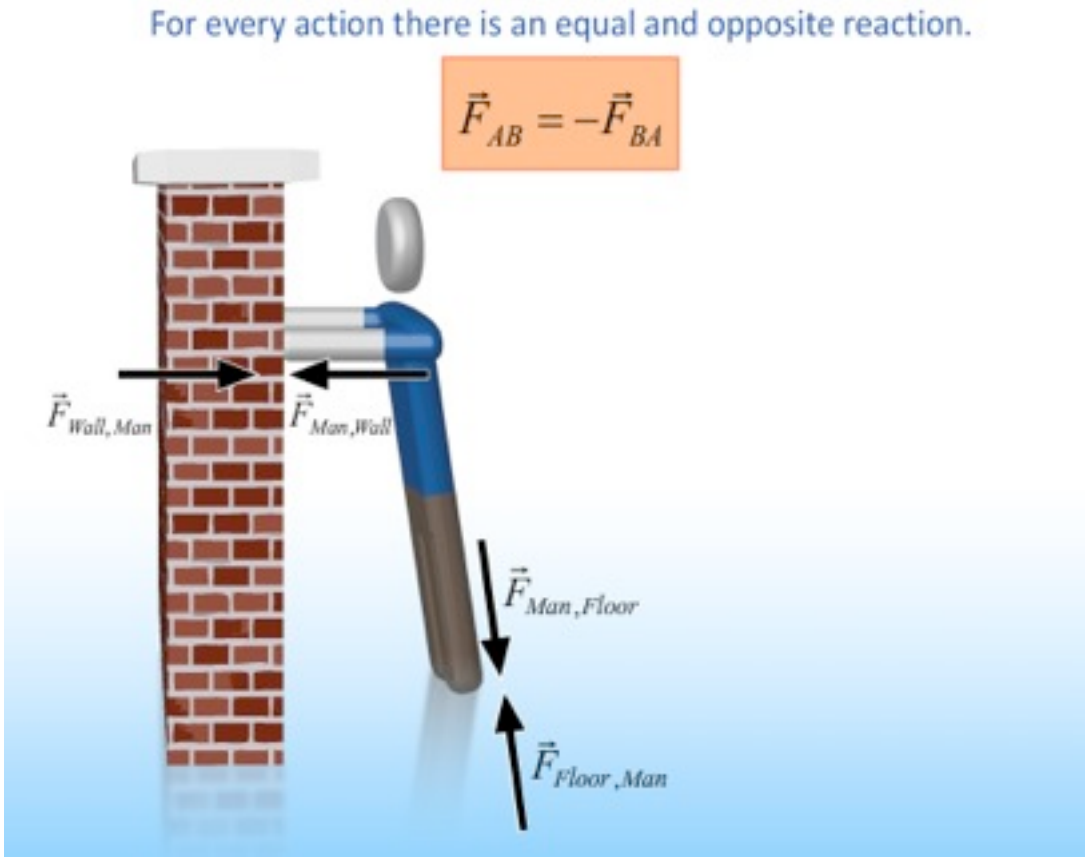
This effect can make cannons miss their target if you don't take it into account.

Hurricane Earl



And makes hurricanes rotate CCW in the Northern hemisphere — CW in Southern.

Newton's 3rd Law

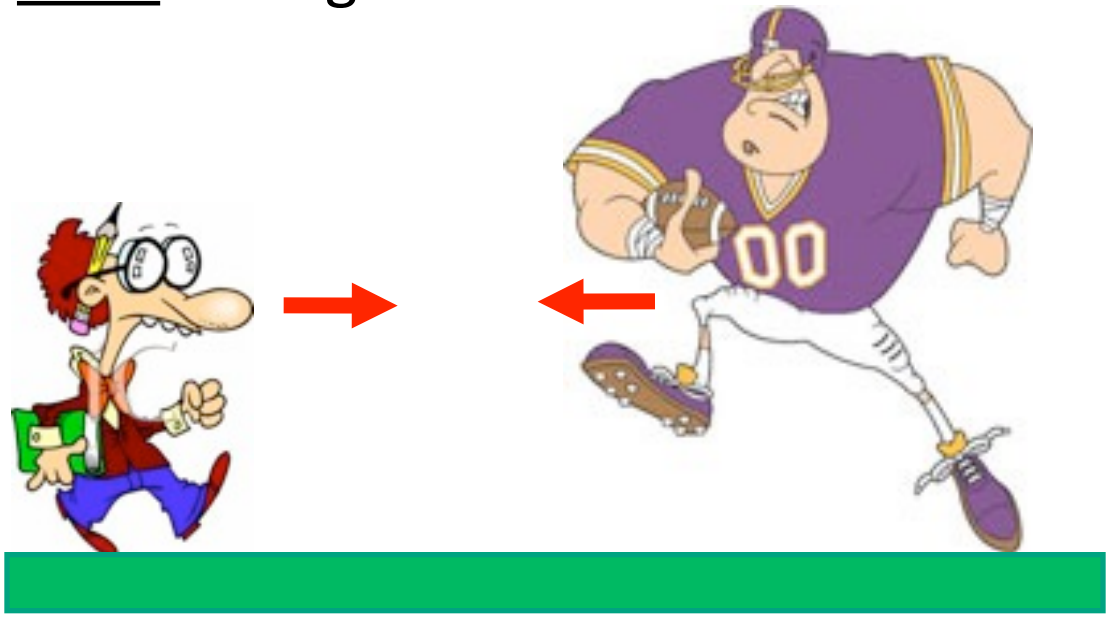


Forces come in pairs!

Fire-cart

Clicker Question

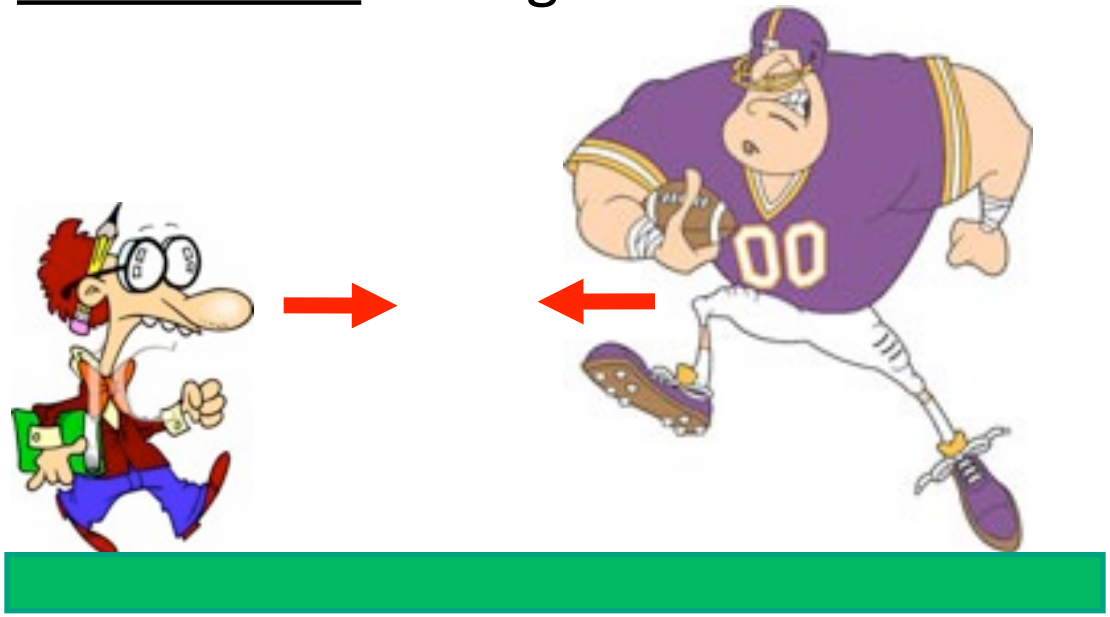
A small guy and a large football player moving at the same speed collide head-on. Which person experiences the larger force during the collision?



A) The small guy.
B) The football player.
C) They experience the same force.

Clicker Question

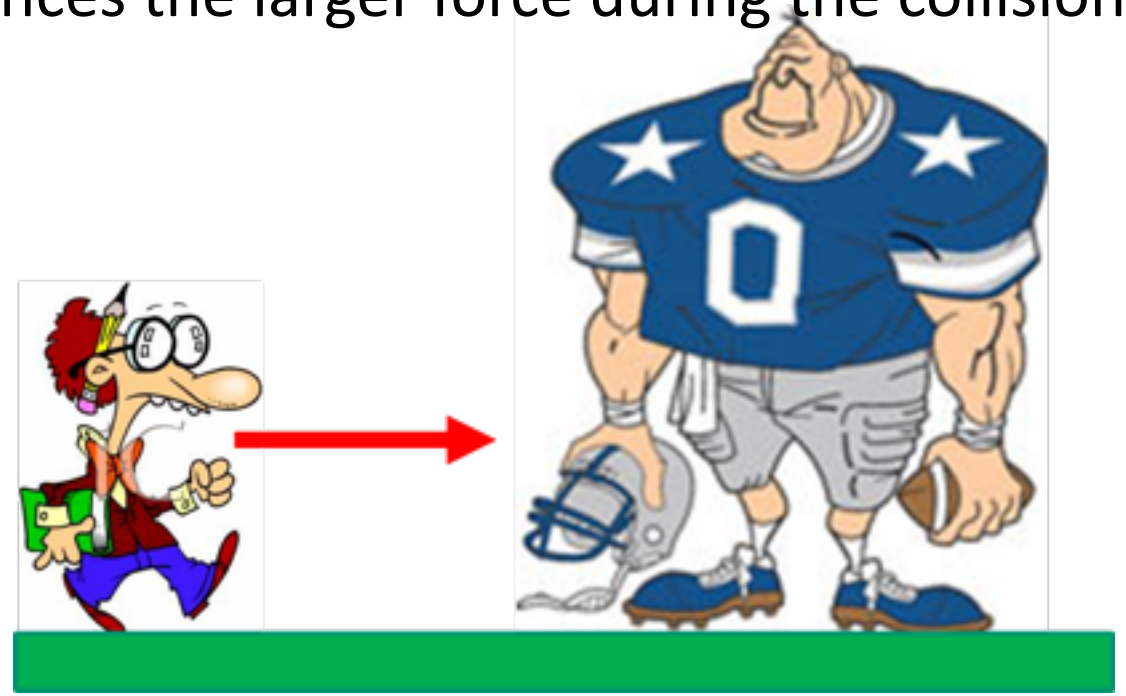
A small guy and a large football player moving at the same speed collide head-on. Which person experiences the larger acceleration during the collision?



A) The small guy.
B) The football player.
C) The accelerations are the same.

Clicker Question

A small guy moving at a high speed collides with a stationary large football player. Now, which person experiences the larger force during the collision?



A) The small guy experiences the larger force.
B) The football player experiences the larger force.
C) Both experience the same force.