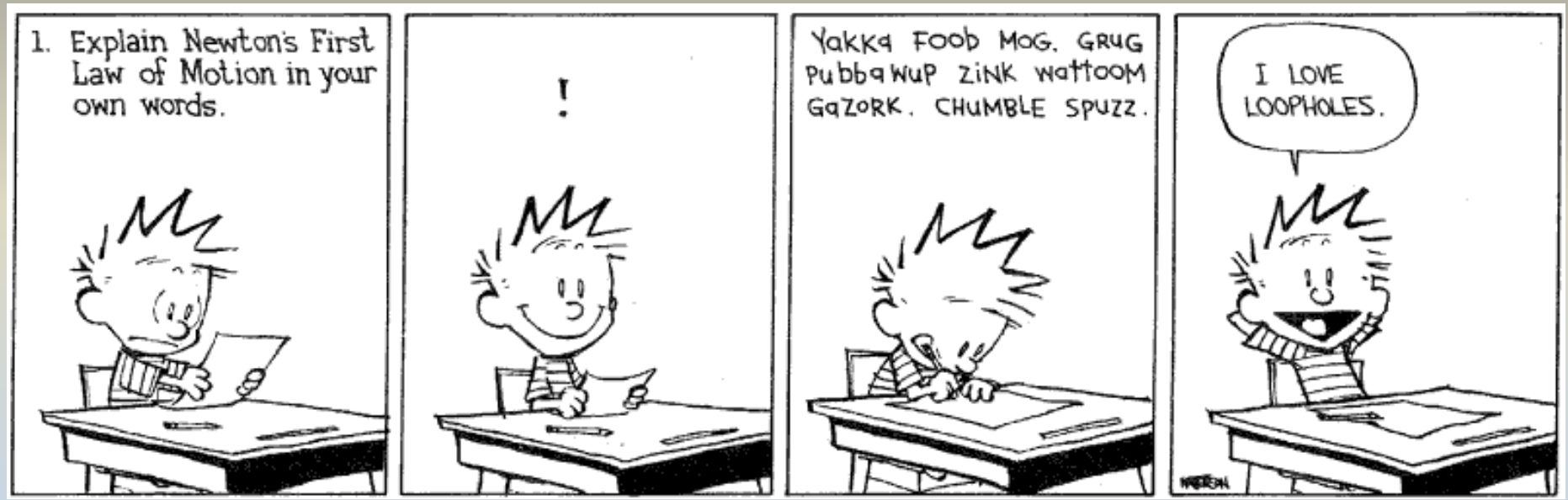
# Physics 2211: *Matter and Interactions*

Todays objective:

Position update and momentum

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Please include: Phys221C

at the beginning of the subject

Howey Room C203

Office Hours: Weds 10-11 am and Fridays 3-4 pm

# Physics 2211: *Matter and Interactions*

- **The position update formula**
  - Combining the definition of the average velocity and the change in position:

$$\vec{r}_f - \vec{r}_i = \vec{v}_{avg} \Delta t$$

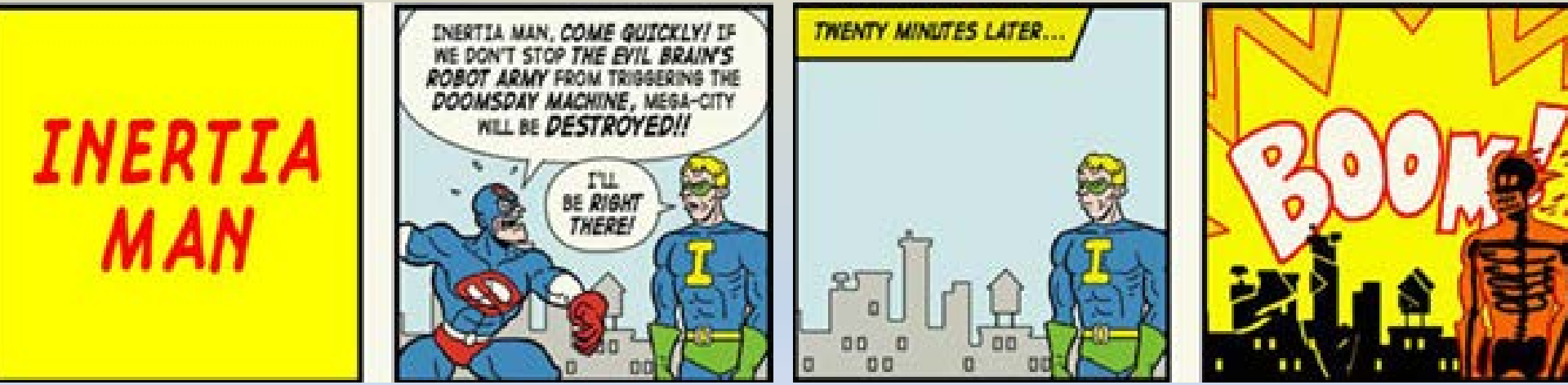
$$\vec{r}_f = \vec{r}_i + \vec{v}_{avg} (t_f - t_i)$$

- **Given information about the average velocity we can determine an new position**
  - Physics allows us to predict the future!
  - How good the prediction is will depend on the accuracy of the average velocity calculation

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

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.



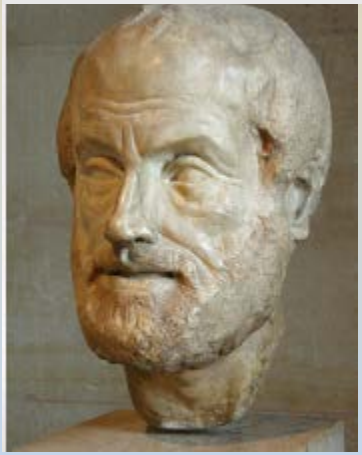

Newton's First Law

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

**Dynamics was primarily determined by the nature of the substance that was moving**

- When we observe a change in an objects velocity we say that it has interacted with something
- Aristotle (384 BC – 322 BC) held that it was an objects natural tendency to be at rest

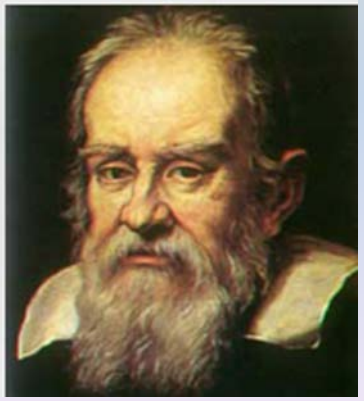


push was ***necessary*** to keep something moving

**"Objects only move if there is a force"**

Galileo: first to introduce the concept of acceleration
first to introduce the idea of inertia

- Galileo (1564 AD – 1642 AD) claimed that an objects natural tendency was to travel in a straight line at a constant speed unless it was interacting with something



**"Forces do not keep objects moving"**

# Physics 2211: *Matter and Interactions*

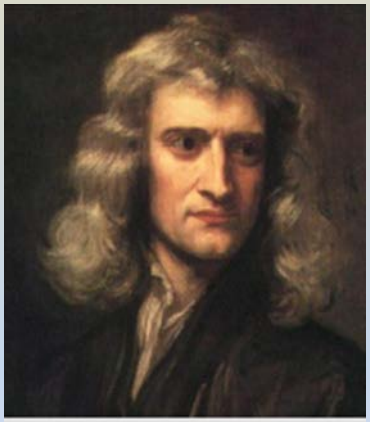
***Class III ( interactions and momentum)***

## About Matter and Interactions:

For example:

- **When we observe a change in an objects velocity we say that it has interacted with something**

Newton (1643 AD-1727 AD)



First Law:

An object tends to be at rest or moves in a straight line and a constant speed except to the extent that it interacts with other objects.

Second Law: A change in Momentum means there is a Net Force acting on the system.

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

The momentum Principle

Momentum: $$if \quad \frac{|\vec{v}|}{c} \ll 1 \quad then \quad \vec{p} \approx m\vec{v}$$

For the rest of the class, we will ask questions **All** can be answer correctly by using this Eq.

Do you really know how to read an Equation?!!

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

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.

Sounds simple (trivial). Took from Aristotle 300s BC, Galileo 1600s AD to Newton 1700s AD. It is 300 years old yet it is taught at high school and University.

Because it is actually profound, it's a basis to build our understanding of interactions.



# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

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.

- **The Momentum Principle:** *The change in momentum of a system is equal to the net interaction (force) acting on the system by the surroundings multiplied by the duration of the interaction*
  - System: *One or more objects of interest*
  - Surroundings: *Everything else in the Universe*
  - Net Force: *The sum of all the interaction (forces)*

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

$$d\vec{p} = \vec{F}_{net}\, dt$$

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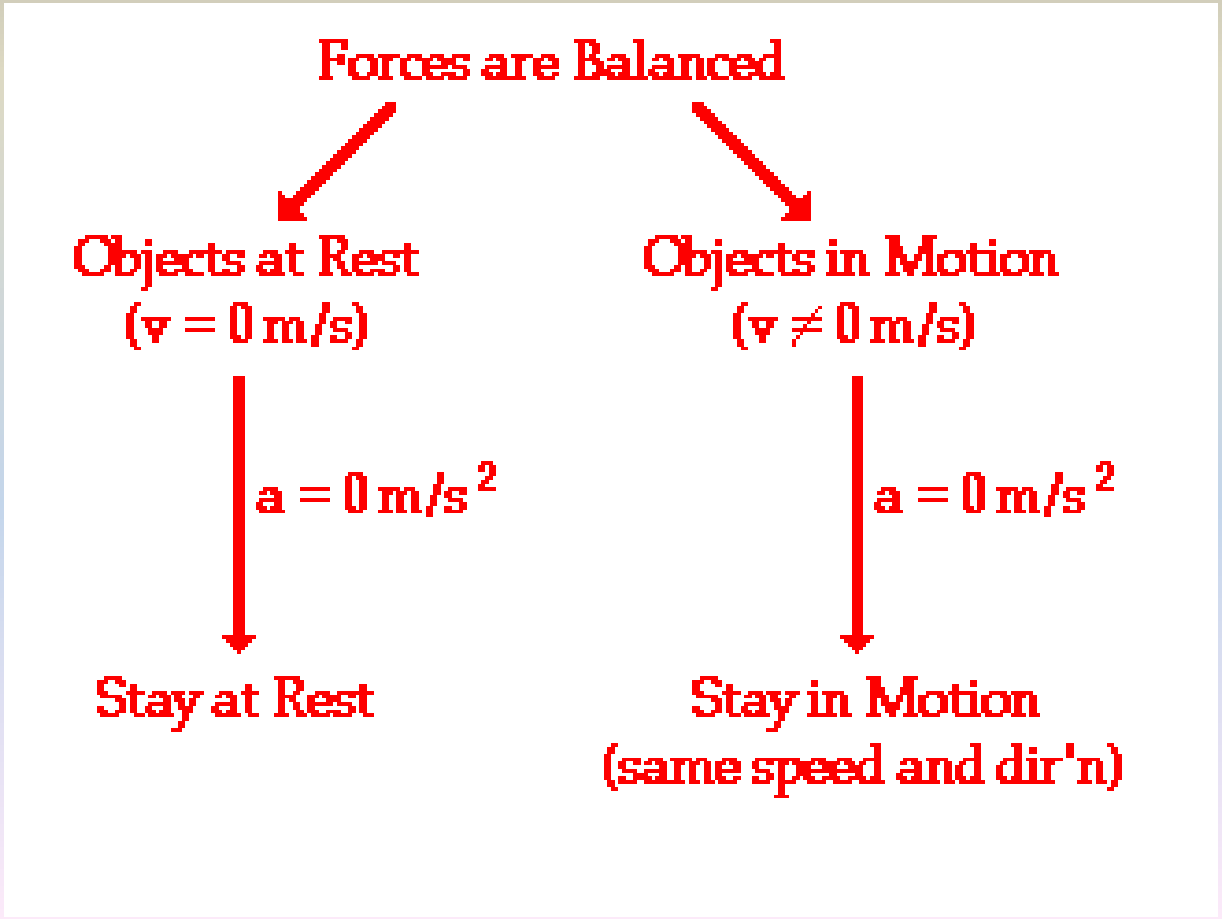
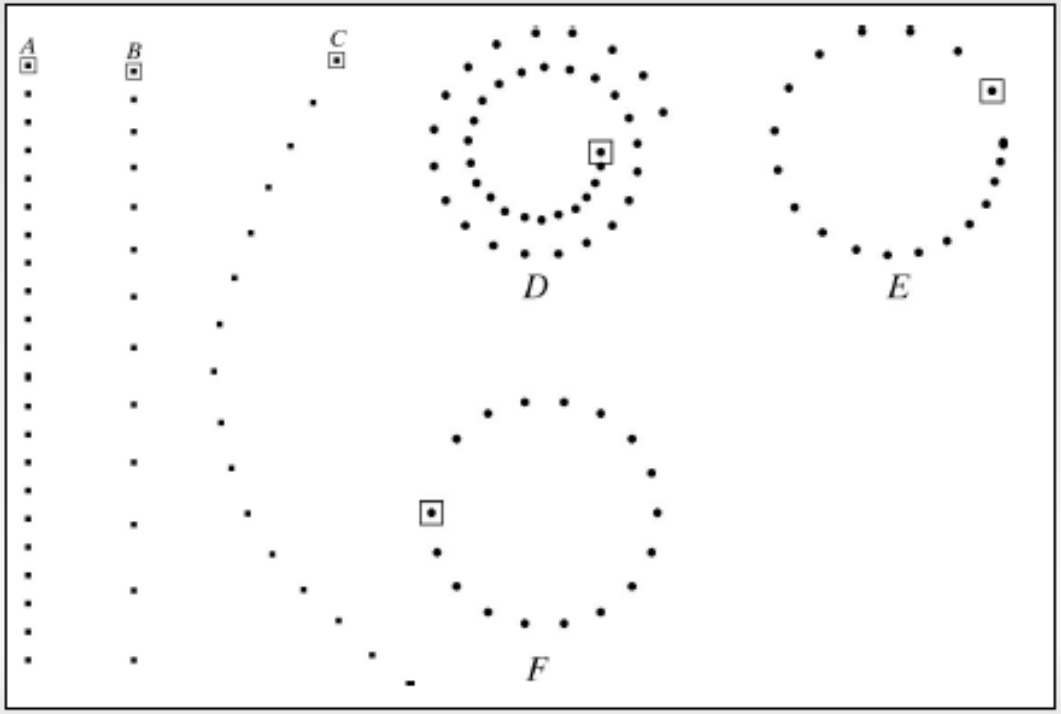



# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

- **Clicker:** *Moving objects left the traces shown at left. The dots were laid down at equal time intervals. Which object(s) did NOT interact with another object somewhere?*




(1) A

(2) B

(3) C

(4) F

(5) A and B

(6) B and F

(7) A, B, D, E

(8) D and E

(9) All of them

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***Class III ( interactions and momentum)***

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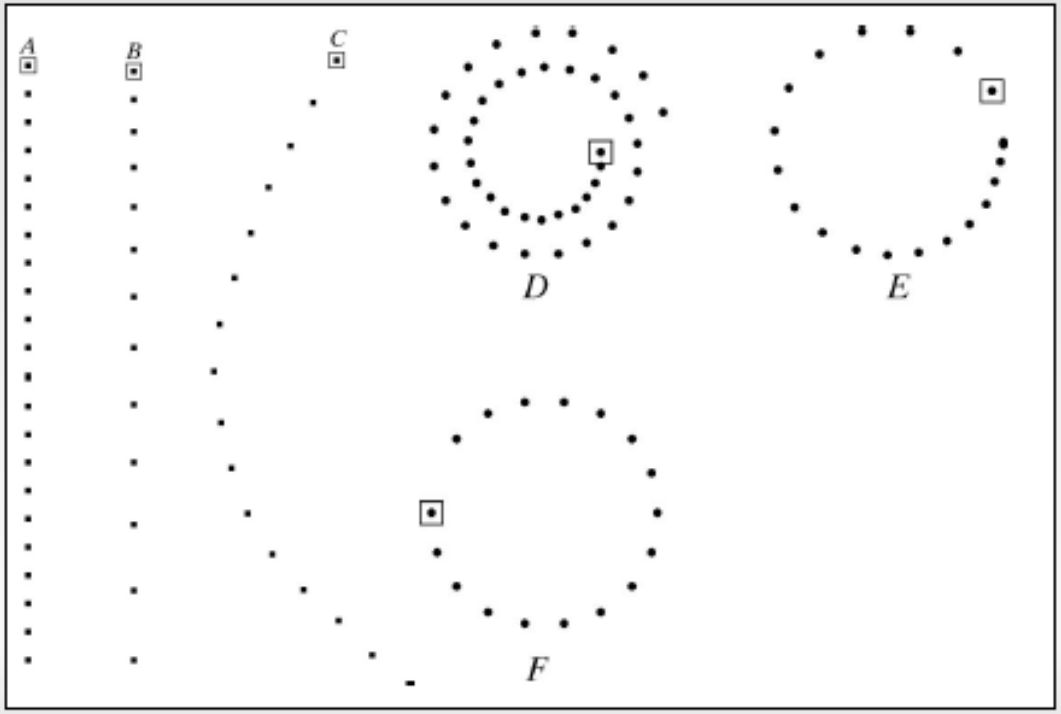


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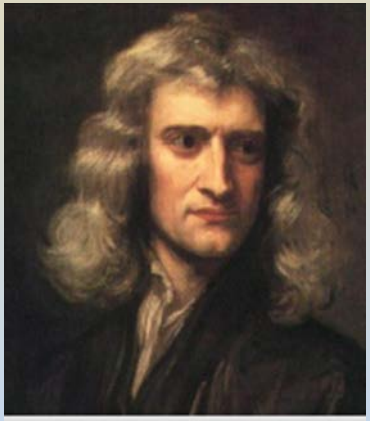
# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

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.

3 Examples



# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

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.

Explains many effects of everyday life, for example:

- The movement/shaking we have riding the subway.
- Walking with a cup full of liquid (lifting).

Spills/Shaking happen when:

- the container/you were at rest and there was an action to move.
- the container/you were in motion and there was an action to stop.
- the container/you were moving in one direction and an there was an action to change direction.

# Physics 2211: *Matter and Interactions*

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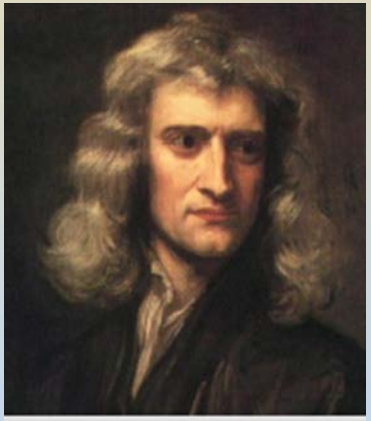

# Momentum and Forces.

**Clicker**: You push a book across a table. In order to keep the book moving with constant momentum, you have to keep pushing with a constant force.

Which statement explains this?

1) A net force is necessary to keep an object moving.
2) To make the net force on the book zero, you must push with a force equal and opposite to the friction force on the book.
3) For the book to move forward with constant momentum you need to exert a force just slightly larger than the friction force.

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# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

Some consequences of Newton's first law:

- We can learn and understand if an object (system) is interacting with something else (surrounding ).
- We can then in many cases predict the motion or future dynamics of that system
- Even for cases where the object keeps interacting or not with the surroundings.

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

How do we know when an interaction is present?

Examples that **Indicate interactions**
changes like:

- Change in velocity (direction, magnitude, or both)
- Change in configuration
- Change in temperature
- Change in form or identity
  (e.g. mass /charge into energy or vise-versa)

The key word being…..

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

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- Change in velocity (direction, magnitude, or both)
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**Note:** Many interactions can be exerted to one object at once!
So if the total interaction is not zero, there has to be a change

**How do we know when an interaction is present?**

If we know that there is an interaction on an object, and yet the object is at rest ...

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.

**How do we know when an interaction is present?**

If we know that there is an interaction on an object, and yet the object is at rest ...

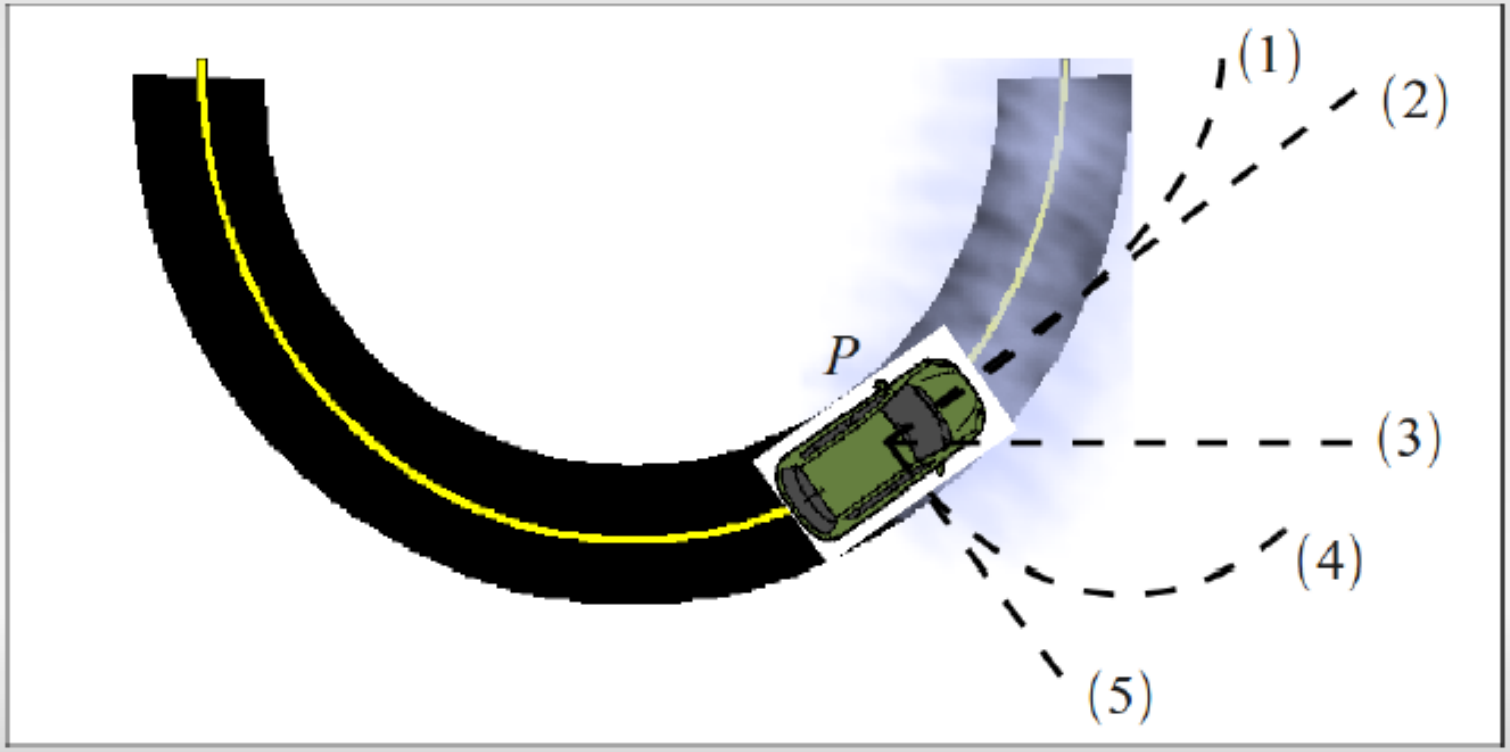
That means that there has to be another interaction that balances the forces.

Example: Normal force (and gravitational force).
holding an object (against gravitational force).

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

- **Clicker:** *A car is navigating a circular turn when it suddenly encounters a large patch of ice at point **P**. On the ice, the car's tires are frictionless. Which path would the car most likely follow after hitting the ice?*



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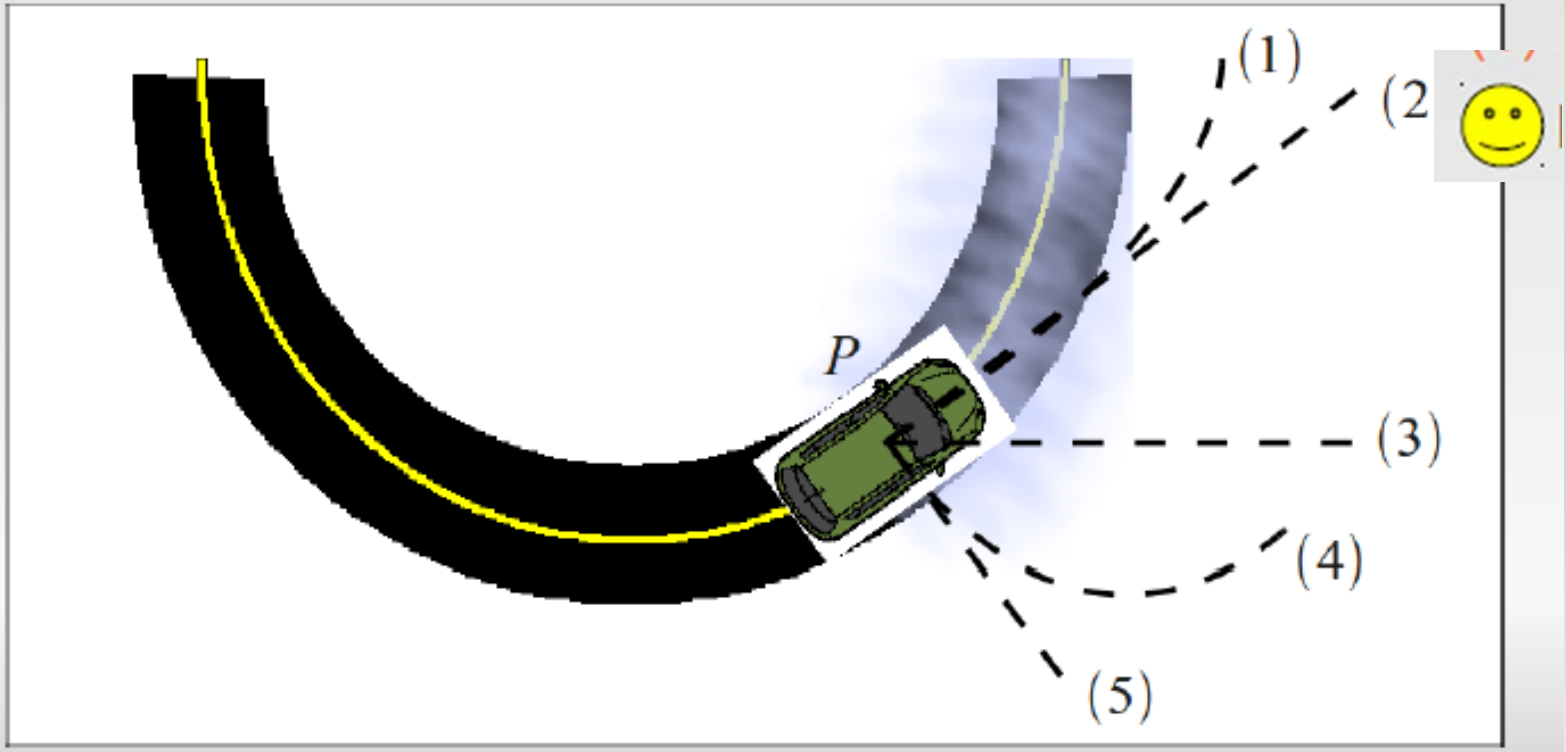
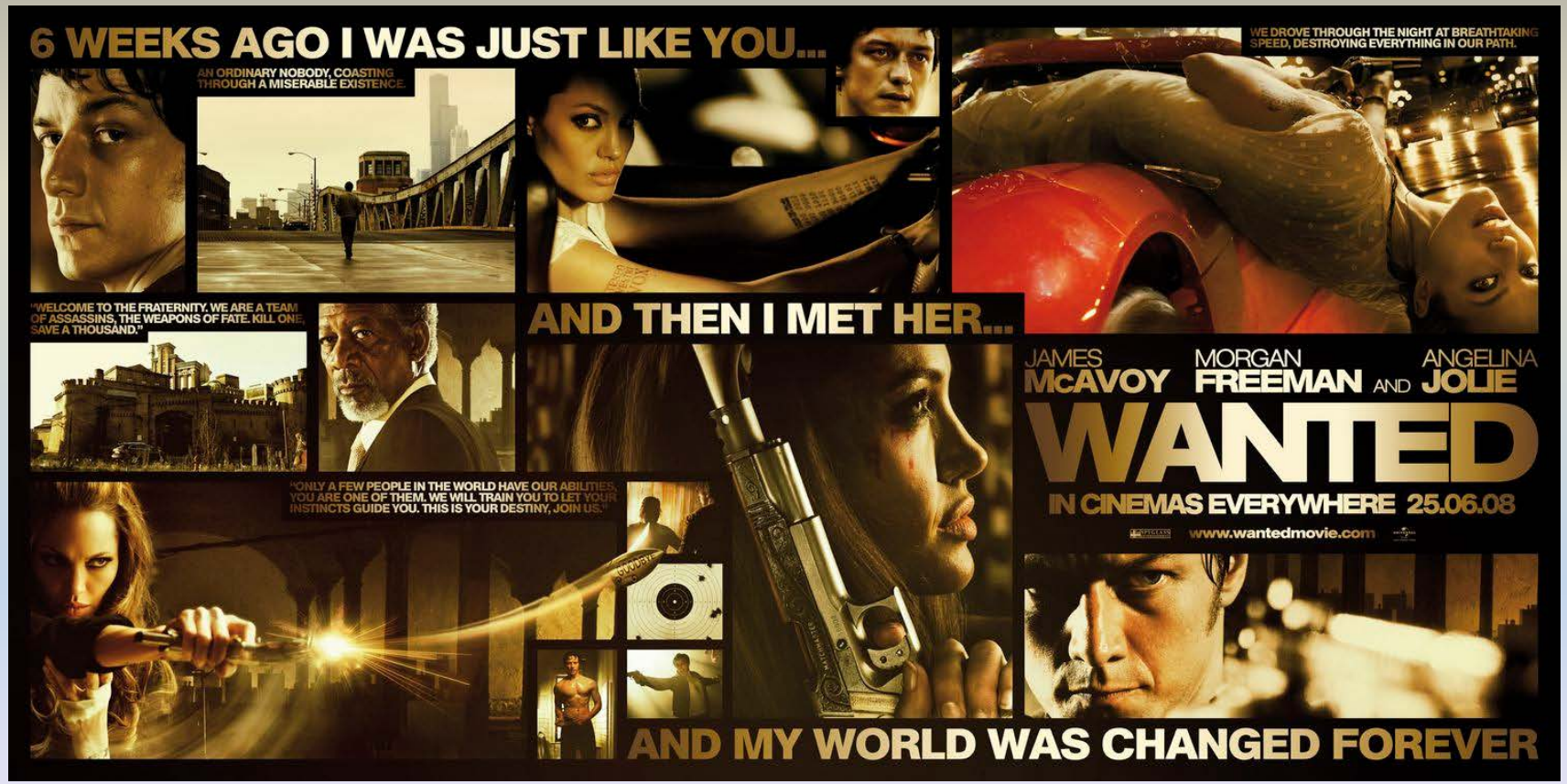


# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

Example: Movie “Wanted”




Is it possible for bullet to travel along bent trajectories?

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***Class III ( interactions and momentum)***

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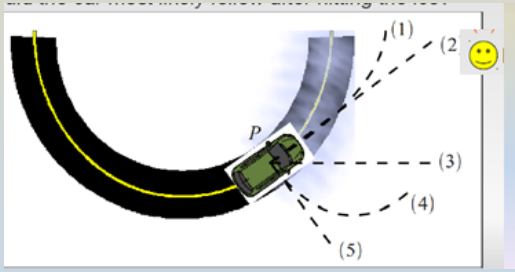



Remember
Our previous example!

NO!

Is it possible for bullet to travel along bent trajectories?

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

Example: What about Roberto Carlos' Goal?

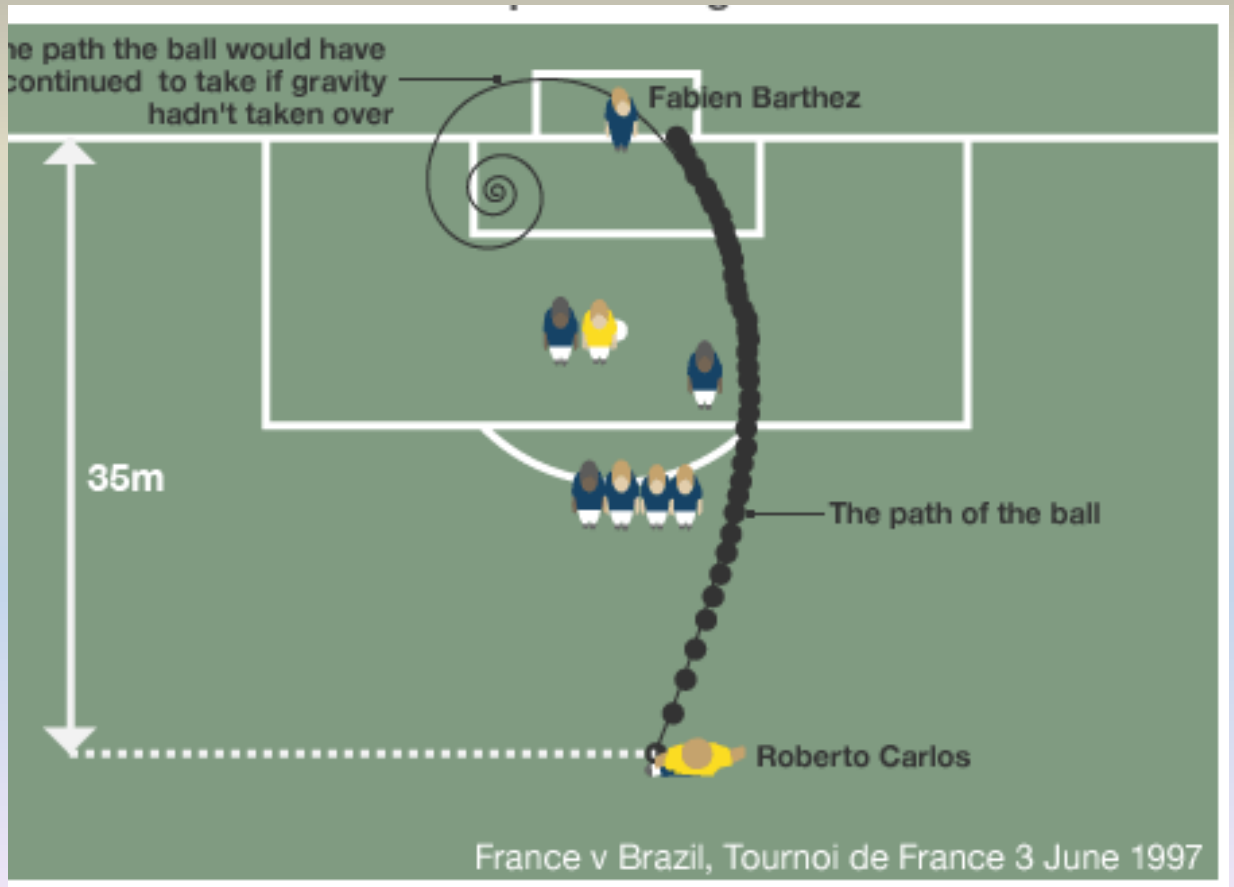
Is it possible for soccer balls to have bent trajectories?

# Physics 2211: *Matter and Interactions*

***Class III ( interactions and momentum)***

Example: What about Roberto Carlos' Goal?

"The Impossible goal"




Is it possible for soccer balls to have bent trajectories?

Therefore:

First Newton's Law:
If there is no Force acting on a system the system is either Static or moving with constant velocity.

Second Newton's Law:
If there is a change in Momentum, that means there is a Net Force acting on the system.

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

The momentum Principle