September 23, 2016 Physics 131 Prof. E. F. Redish

- **Theme Music: Fleetwood Mac**

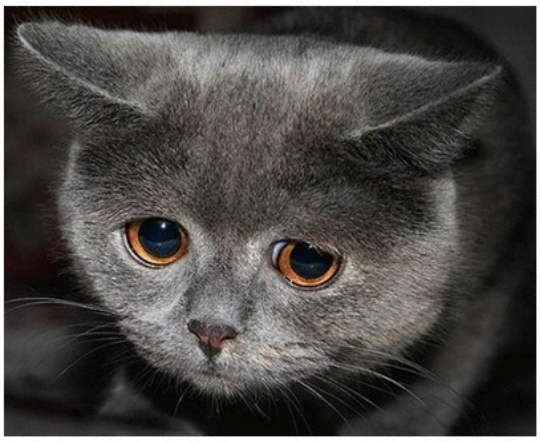
  Don't Stop

- **Cartoon: Jef Mallet**

  Frazz

Note

I'm very aware that solutions to some of our problems have found their way to the internet, so it's trivial to "cheat" on some problems and cut and paste solutions instead of working them out. If you do this, not only will it be obvious to the TAs (we have search engines too), but you will lose the opportunity to learn what you are supposed to learn from doing the work, with consequences for your exams. (If our spot checks catch you we will send it to the judicial board.) And every time someone hands in a cut-and-paste solution, **this kitten gets sadder**. If you can live with that, so be it. You monster.



Comment on clickers

- Clicking with someone else's clicker is a violation of the honor code and could lead to your clickers being confiscated and your being given a grade of XF in this class that would go on your transcript.

Foothold principles: Newton's Laws

- Newton 0:
  - An object responds **only** to the forces it feels and only at the instant it feels them.
- Newton 1:
  - An object that feels a net force of 0 keeps moving with the same velocity (which may = 0).
- Newton 2:
  - An object that is acted upon by other objects changes its velocity according to the rule $\vec{a}_A = \vec{F}_A^{net} / m_A$
- Newton 3:
  - When two objects interact the forces they exert on each other are equal and opposite. $\vec{F}_{A\to B}^{type} = -\vec{F}_{B\to A}^{type}$

Newton's 2nd Law (conceptual form)

$$\Delta v = \mathscr{I}/m$$

$$\Delta x = v\Delta t$$

- Where
  - $\mathscr{I}$ is the "impulse" (something delivered to the object by another object touching it)
  - m is the "mass" (a property of the object that says how many bowling balls it is equivalent to)

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A More Familiar Form

- If the object that is causing the change of velocity by exerting a force for a certain (small) amount of time.
- Then we get

$$\mathscr{I} = F\Delta t$$

$$\Delta v = \left(\frac{F}{m}\right)\Delta t \qquad \Delta x = v\,\Delta t \quad \rightarrow \quad \frac{dv}{dt} = \frac{F}{m} \qquad \frac{dx}{dt} = v \quad \rightarrow \quad a = F/m$$

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Reading question

- Since the equation $a = F^{net}/m$

  is not the definition of acceleration,
  then is

  $$F^{net} = ma$$

  not the definition of force?
  If not, what is the definition of force?

Technical term alert: What's a Force?

- The "F" in Newton's law is an expression of the idea:
  - When two objects interact they do something to each other that tends to change the other's velocity.
  - Our intuition on which this is built is the feeling of a push or pull.
- Although the technical term for this is "force" it is somewhat different from the common speech idea of force.
  - It is an interaction between two objects.
  - It only occurs via contact or by the non-touching examples of gravity, electricity, and magnetism.

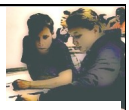
The Newtonian Framework helps us learn to see "hidden" Forces

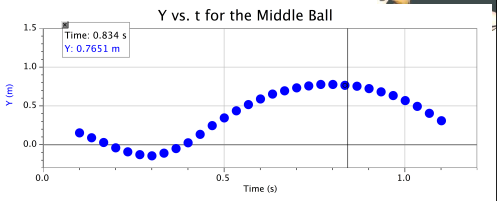
- Contact forces are hard to measure directly.
- We infer them from Newtonian principles.
- Consistency is a good test as to whether our model of invisible forces is good (and sometimes we can actually measure them)

Even if we have a new name for it, what the &*$#% is it?

- "Force" is what an interaction between two objects does to each object that tends to change its velocity.
- How can we operationally figure out what a force is?
- Process:
  - Define some force that can set a quantitative measurable standard (spring)
  - Measure object's masses by seeing how much a standard force accelerates them.
  - Create models of new forces (as, perhaps, functions of position) by seeing how they accelerate objects.
  - Use our force models to predict motions.
  - If we quickly stop having to add new forces we have a stable structure.

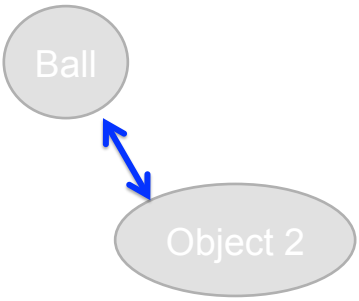
What causes/changes Motion?





Whose motion we are describing?

An object of interest (the ball)



What causes or changes its motion?

Other objects interacting with ball

Draw a System Schema that would be appropriate for talking about what causes the motion of the ball.

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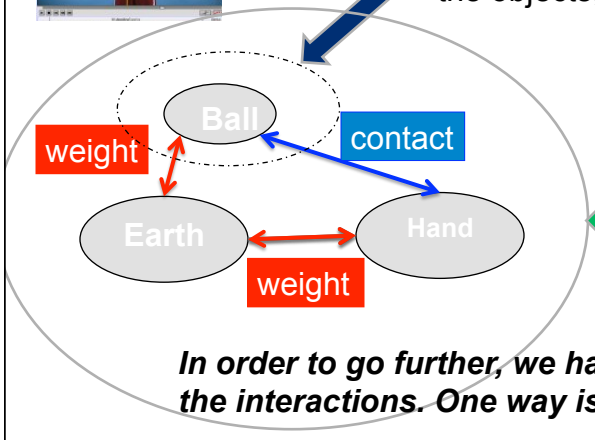
System Schema

We want to understand & calculate what causes the motion of one of the objects, **the ball.**



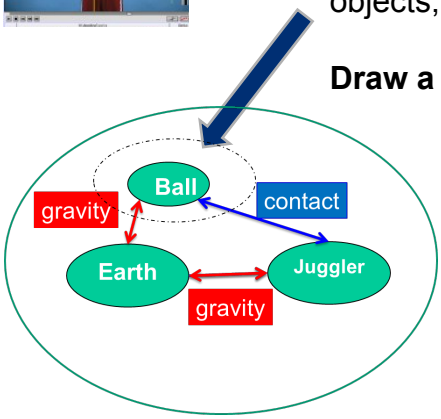
The Ball interacts with other objects, it is part of a system

In order to go further, we have to model the interactions. One way is with forces.

The Free Body Diagram

We want to understand & calculate what causes the motion of one of the objects, **the ball.**

Draw a Free Body Diagram for Ball



$\vec{F}^{net} = ??$ Ball

Kinds of Forces

- Forces are what objects do to each other when they interact.
- Types of Force
  - Normal: N
  - Tension: T
  - Resistive: f, F^D, F^V
  - Weight: W
  - Electric: F^E
  - Magnetic: F^M
- Notation convention.

$\vec{F}$ type of force
(object causing force)→(object feeling force)