

September 24, 2013

Physics 131

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- **Theme Music: When Push Comes to Shove**
Greatful Dead
- **Cartoon: Rick deTorie**
One Big Happy



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System Schemas

- A tool that allows you to be explicit about defining what you are going to choose to talk about and with how much complexity you are going to treat it.
- Specify
 - Relevant objects (and structures if needed)
 - Interactions between objects

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Thinking about motion



- Consider dog 2 in the two-dog tug-of-war.
- Draw a SS on your whiteboard that identifies the influences acting on him.



He isn't moving

- Yet there are clearly interactions that tend to make him move. What are they?
- Why doesn't he move?
- Is he also acting on the things that are acting on him?
- If so, why don't they move?

But...?



- If no (horizontal) forces on you car means it keeps going at a constant speed, why do you have to push things to keep them going at a constant speed?
- Don't things naturally tend to stop and you have to push them to keep them going? That feels physically intuitive.
- Can you come up with examples that feel physically intuitive where things tend to keep going and you have to push them to make them stop?

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Conceptual ideas underlying Newton's Laws: 1



- Objects respond only to influences acting upon them at the instant that those influences act. (**Object egotism**)
- All outside effects on an object being equal, the object maintains its velocity (including direction). The velocity could be zero, which would mean the object is at rest. (**Inertia**)
- Every change in velocity an object experiences is caused by the object interacting with some other object – forces. (**Interactions**)

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Conceptual ideas underlying Newton's Laws: 2



- If there are a lot of different objects that are interacting with the object we are considering, the overall result is the same as if we add up all the forces as vectors and produce a single effective force -- the *net force*. (**Superposition**)
- When one object exerts a force on another, that force is shared over all parts of the structure of the object. (**Mass**)
- Whenever two objects interact, they exert forces on each other. (**Reciprocity**)

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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. $\vec{F}_{A \rightarrow B}^{type} = -\vec{F}_{B \rightarrow A}^{type}$

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Newton's 2nd Law (conceptual form)

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

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

- Where
 - \mathcal{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

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

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

$$\Delta x = v \Delta t \quad \rightarrow \quad \frac{dx}{dt} = v$$

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Models of Systems

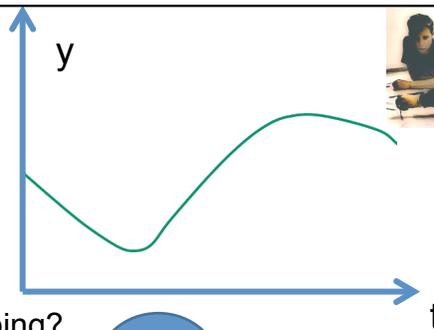
- The Newtonian principles create the framework: now we need to build models of specific situations.
- The SS specifies a basic model – objects and interactions.
- Then we have to specify the properties of the objects (mass, structure) and make models of the interactions. These are *forces*.

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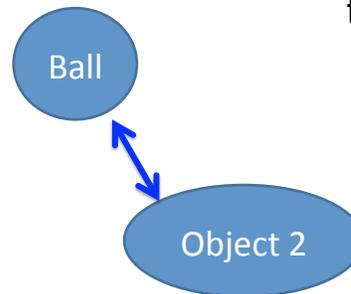
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What causes Motion?



Whose motion we are describing?
An object of interest (the ball)

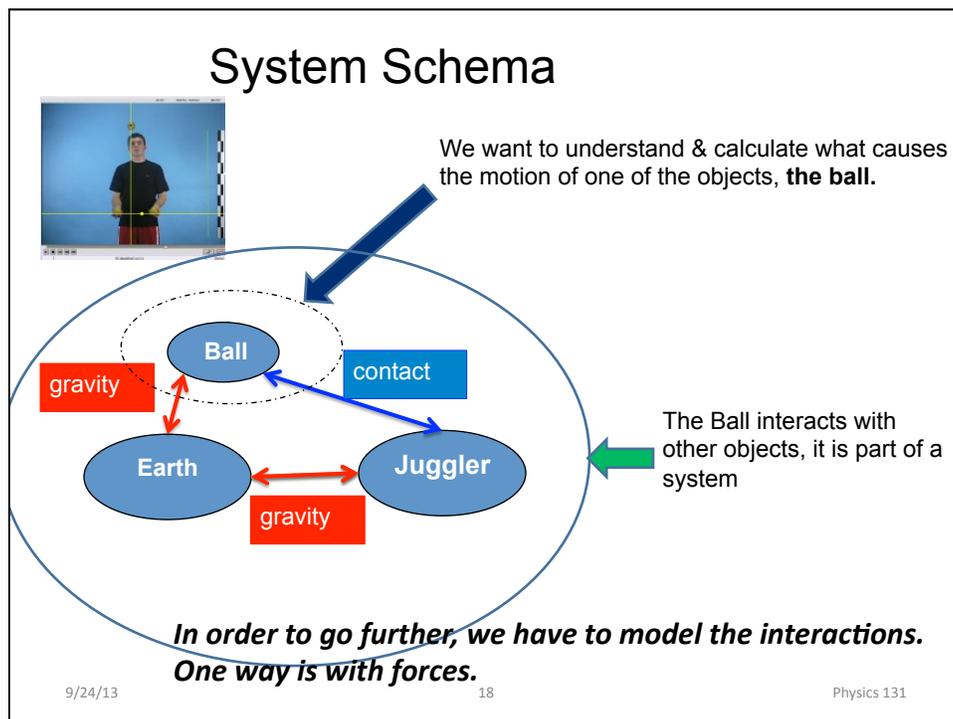
What Causes its motion?
Other objects interacting with ball



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

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Reading question

- Since the equation $a = F/m$ is not the definition of acceleration, then is $F = ma$ 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.
- Although the technical term for this is “force” it is 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.

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

- How can we “define” a force?
- What would a definition look like?
- 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.

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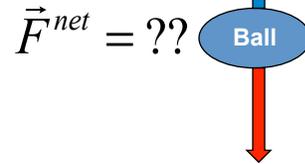
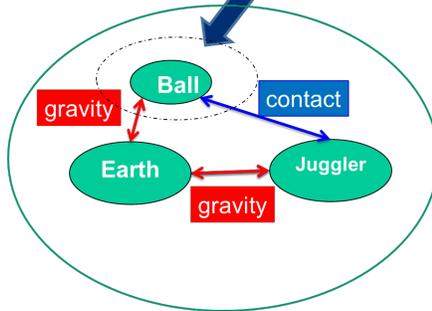
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The Free Body Diagram



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

Draw a Free Body Diagram for Ball



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