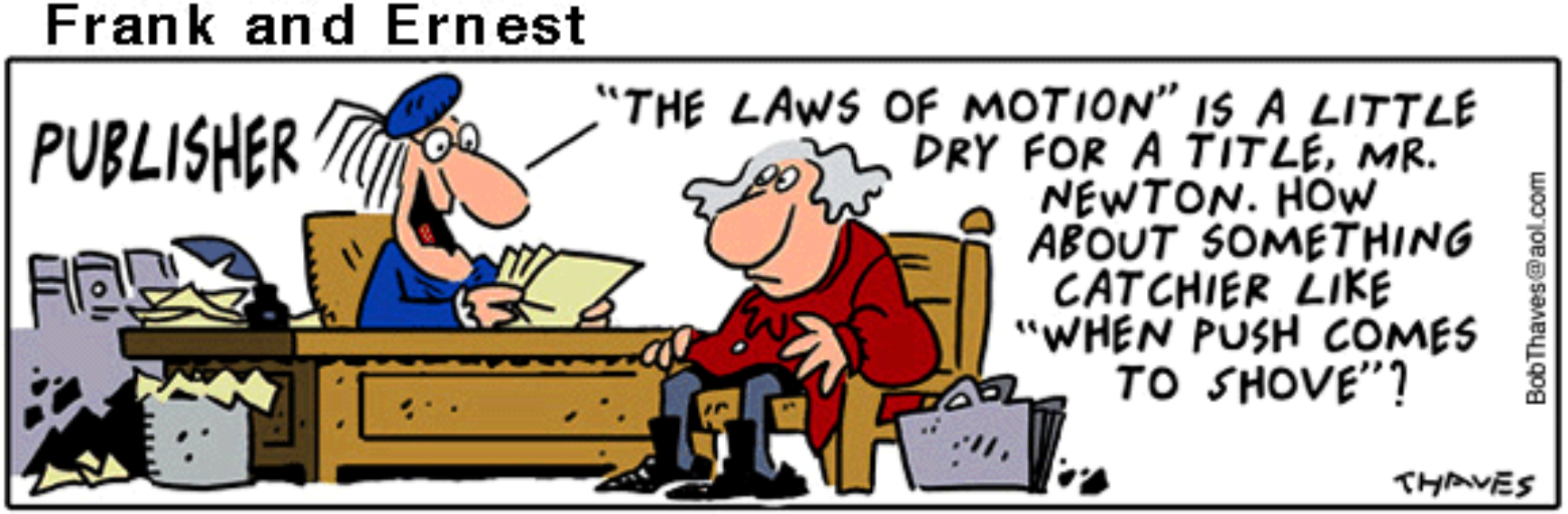
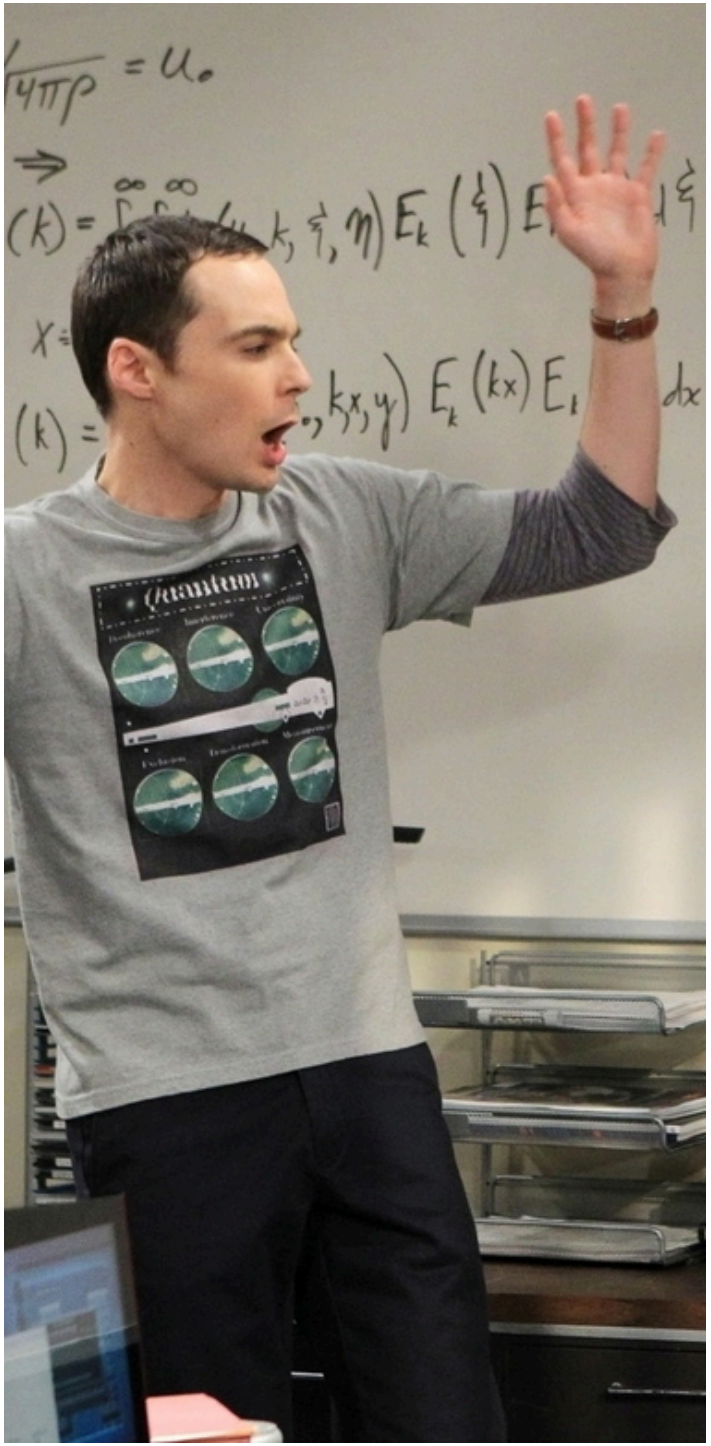
- **Theme Music: Soul II Soul**

  Keep on Movin'

- **Cartoon: Bob Thaves**

  Frank & Ernest





The Equation of the Day

Newton's second law

$$\vec{a}_A = \vec{F}_A^{net} \Big/ m_A$$

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

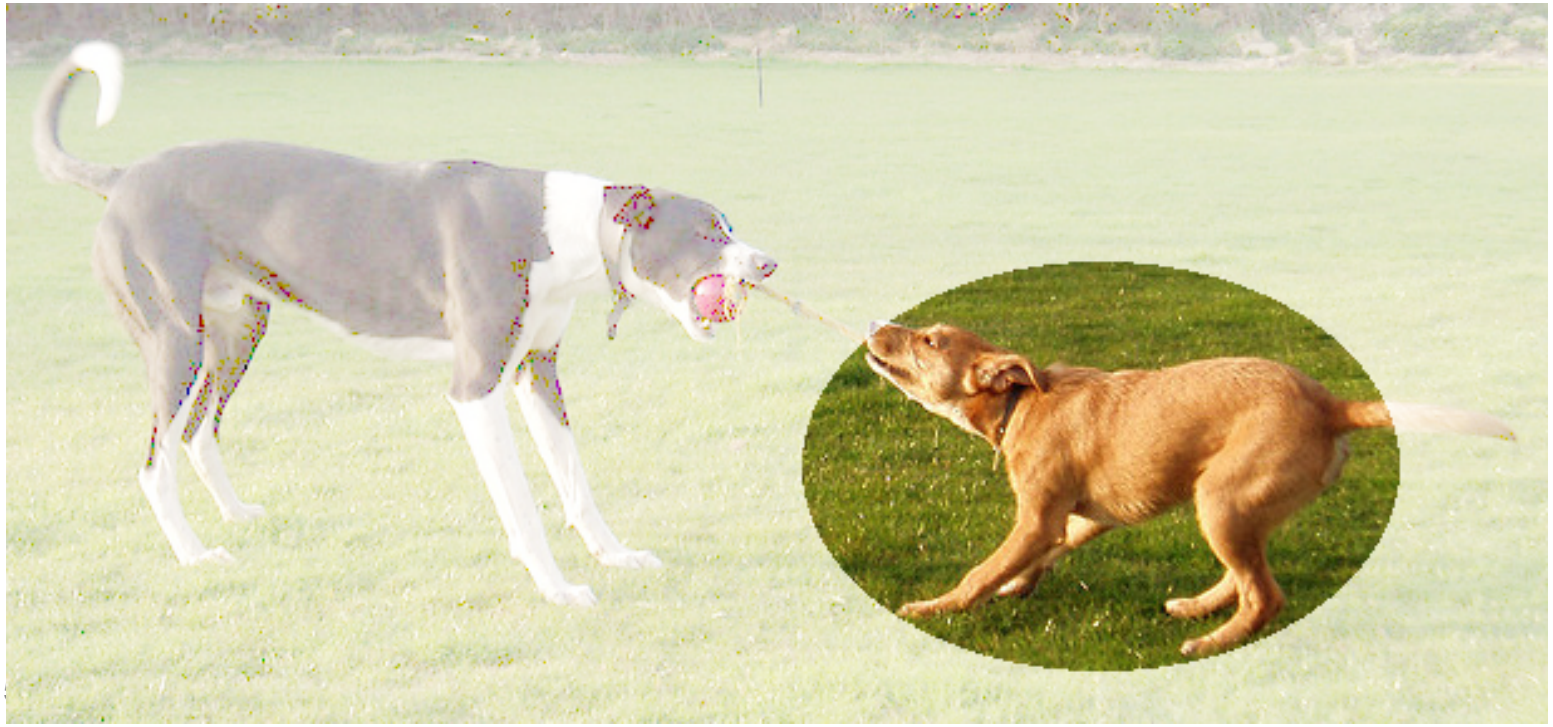
Systems

- We will be considering situations in which many things acting on each other.
- In order to make sense of what's going on, we will focus on a few at a time and create models of what we think is happening.
- Sometimes we will focus on a set of things as our "system" and consider the influence of everything else as "external".
- Some times we will consider something's internal structure; other times we will consider it as a "black box".

System schemas

Thinking about motion

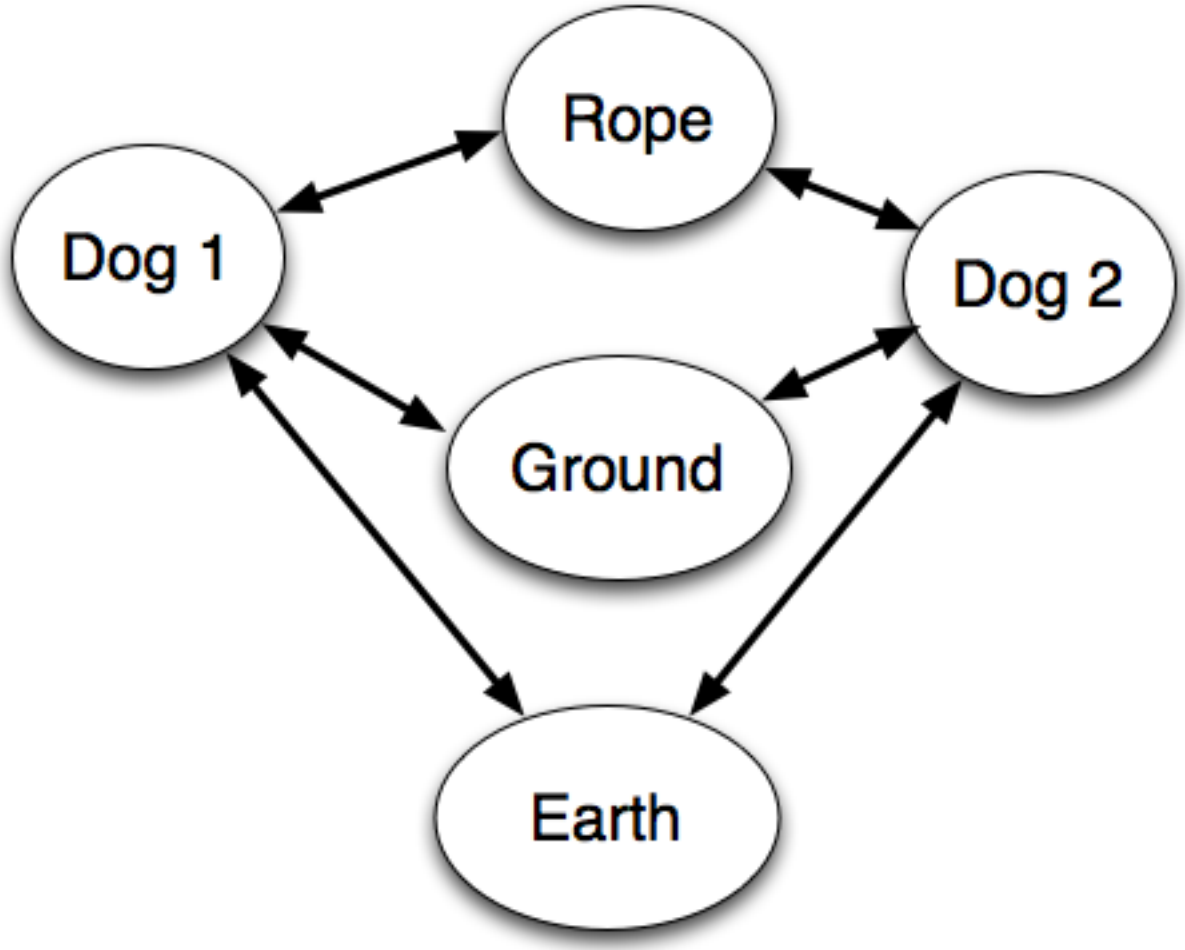
- Consider dog 2 in the two-dog tug-of-war.
- Draw a SS in your notebook that identifies the influences acting on him.



What “things” should be considered when thinking about what influences the motion – or non-motion – of the dogs?

How do they act on each other?

The System Schema for the two-dog tug-of-war



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?

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**)

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**)

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

$$\vec{a}_A = \vec{F}_A^{net} \Big/ m_A$$

- 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)

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

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

$$\Delta v = \left(\frac{F}{m}\right)\Delta t \qquad \Delta x = v\ \Delta t$$

$$\rightarrow \quad \frac{dv}{dt} = \frac{F}{m} \quad \frac{dx}{dt} = v \quad \rightarrow \quad a = F/m$$

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.*