September 16, 2011 Physics 131 Prof. E. F. Redish

- **Theme Music:** **Run Like an Antelope**
  Phish
- **Cartoon:** **Rick deTorie**
  One Big Happy

Outline

- Acceleration: What is it at the top?
- Inventing Newton's Laws
- Foothold ideas
- Forces

What have we learned? ☑

- Position $\hat{r} = x\hat{i} + y\hat{j}$
  (where x and y are signed lengths)
- Velocity $\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t}$ $\vec{v} = \frac{d\vec{r}}{dt}$
- Acceleration $\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t}$ $\vec{a} = \frac{d\vec{v}}{dt}$
- Seeing from the motion
- Seeing consistency (graphs & equations)

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What Causes Motion? Drawing experience

- What do the following motions feel like?
  - No motion (at rest).
  - Constant velocity.
  - Constant acceleration.
  - Changing acceleration (jerk)
- What produces motion?

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Causing Motion

- How do we get something to move?

Block on a table

- Crucial question: What happens to a moving object if nothing acts on it? (or if everything acting on it cancels?)

One more icon: Shopping for Ideas

- What we need to do here is consider some different possibilities and evaluate them to see how well they work for us.

Conceptual ideas underlying Newton's Laws

- 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)
- 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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Alternative Laws of Motion

- Redish's Law (from block on table)

$$\mathscr{T} = \Delta x$$

- Newton's Law (from ball on hard floor)

$$\mathscr{T} = \Delta v$$

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Newton's law of motion

- As a result of taps

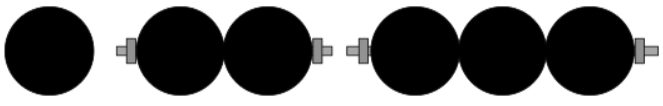
$$\mathscr{T} = \Delta v$$

- Between taps

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

Is "tap" the right concept?

- Is a "tap" ($\mathscr{T}$) the right concept?
- Is it really something the hammer gives to the ball?
  Or does the "tap" also depend on the ball?
- Consider multiple bowling balls ganged together with long bolts.



Impulse

- We expect (and would find if we actually did the experiment) that the effect of a given "hit" with a hammer produces a smaller effect (less Δv) for more bowling balls.
- We therefore replace the "tap" by an "impulse" — something delivered by the hammer to the object.

$$\mathscr{T} = \frac{\mathscr{I}}{m}$$

$\mathscr{I}$ ⟵ delivered by hammer to object

m ⟵ number of bowling balls

Newton's 2nd Law

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

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

- 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)