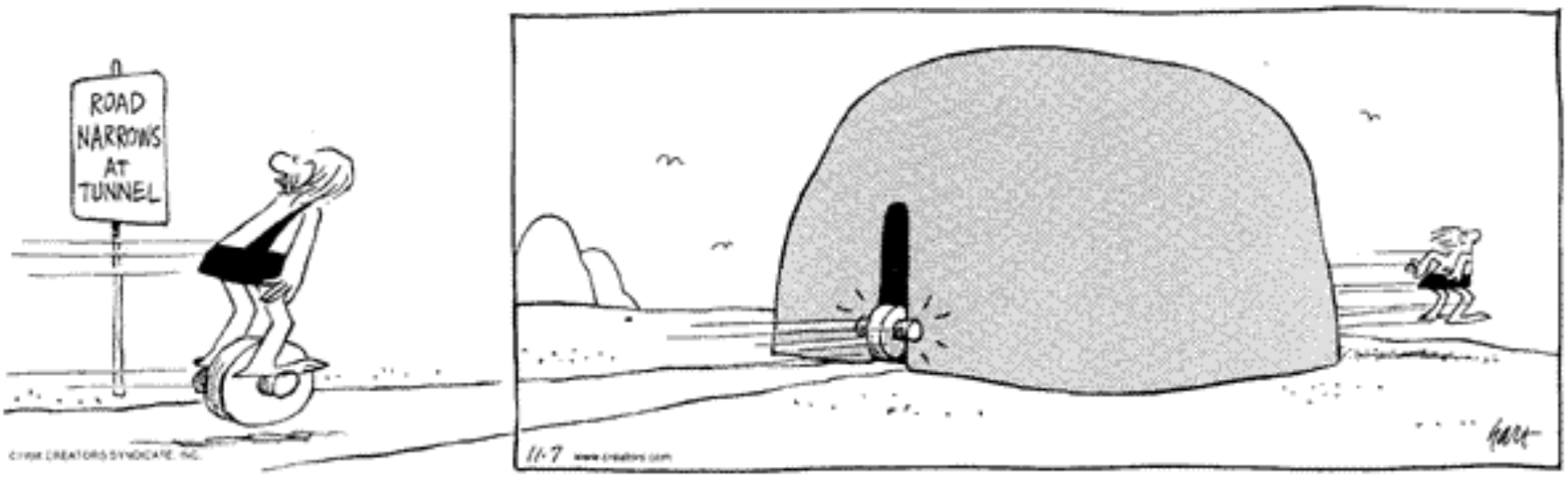
- **Theme Music: Soul II Soul**

  Keep on Movin'

- **Cartoon: Johnny Hart**

  BC



Outline

- Quiz 2
- Acceleration recap
- Finish ILD #2
- Inventing a law of motion
- Newton 2
- Critical assumptions
- Defining force
  - operational definition
  - classifying forces

What have we learned? ☑

- Position $\hat{r} = x\hat{i}$ (where x is a signed length)
- 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)

ILD 2

What if something
just doesn't make sense?

Acceleration at the peak

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?

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.

Alternative Laws of Motion

- Redish's Law (from block on table)

$$T = \Delta x$$

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

$$T = \Delta v$$

Newton's law of motion

- As a result of taps

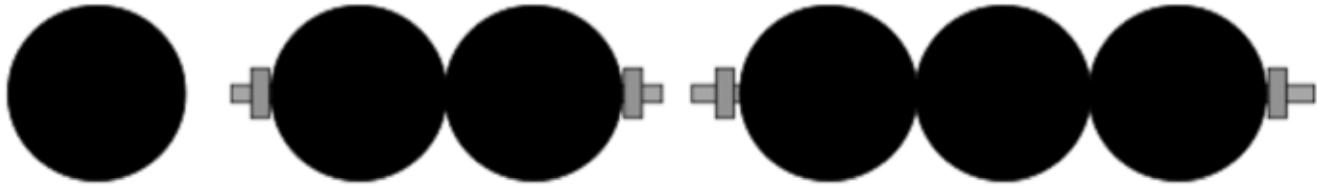
$$T = \Delta v$$

- 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.

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

I ⟵ delivered by hammer to object

m ⟵ number of bowling balls

Newton's 2nd Law

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

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

- 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)

A More Familiar Form

- If the object that is causing the change of velocity by touching our object doesn't "tap" it but touches it continually, it's more convenient to extract a time by writing

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

- then we get

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

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

$$a = F/m$$

Two Important Principles

- Newton 1:
  - If all the influences (forces) acting on an object are balanced (or zero) the object keeps whatever velocity it has.
- Newton 0:
  - An object responds to the forces that act on it at the instant considered.
    (Objects have no long range sensors and no memory for anything except their velocity.)

Newton 0:
Thinking inside the box

- "Physics by empathy"
- "Method acting" – an acting technique in which actors try to replicate real life emotional conditions under which the character operates, in an effort to create a life-like, realistic performance.
  - "What's my motivation?"