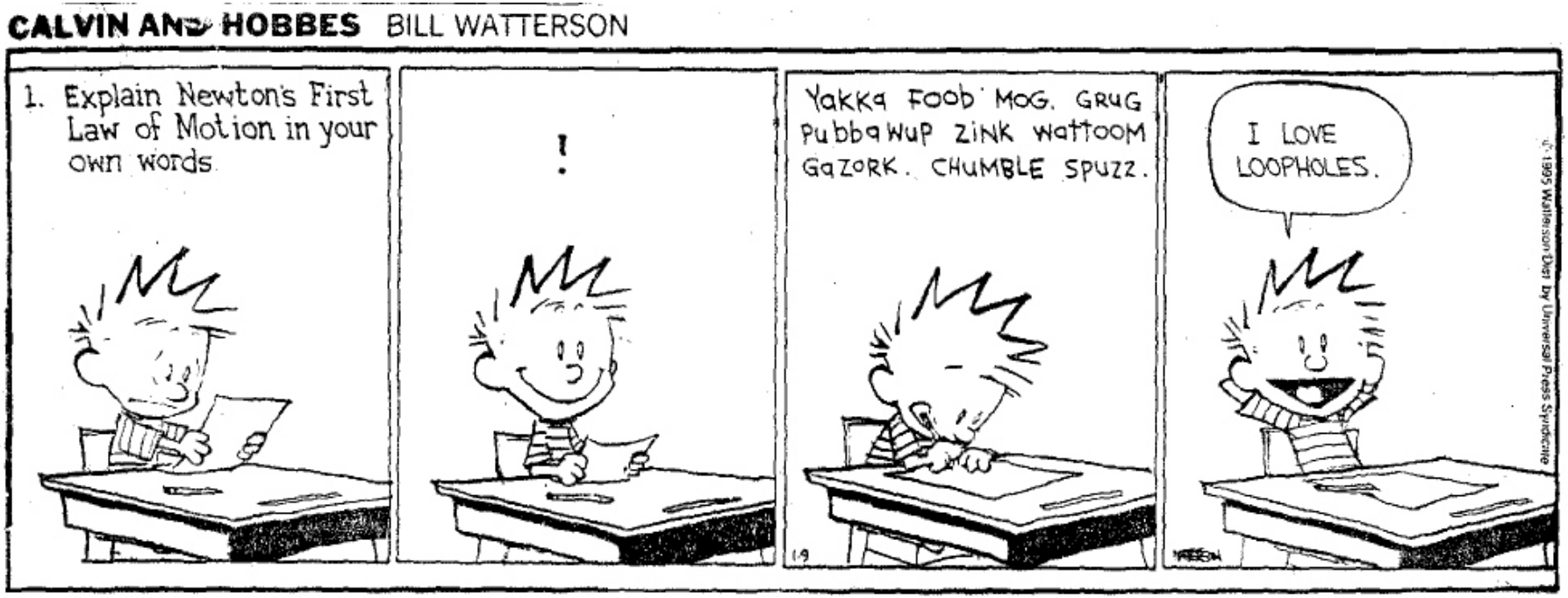
- **Theme Music: Fleetwood Mac**

Silver Springs

- **Cartoon: Bill Watterson**

Calvin & Hobbes



Foothold Principles
Newton's Laws

- Newton 0:
  - An object responds to the forces it feels when 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.

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

Reading questions (N3)

- If Newton's 3rd law does not apply unless the same type of force is under consideration, this means the force normal to the object and the force of gravity are not an example of this law, even if their values are equal but opposite. Why has the 3rd law not been revised in a more broad sense to exclude the "same type of force" portion, if the required calculations are the same?
- If the law states that when one object exerts a force on another object, that other object will exert a force that is equal but opposite, then how is it that often, one force from one object will cause the other to move? If the forces are equal, shouldn't the objects stay still?
- Why isn't the resistive force of B->A considered in the diagram pertaining to object B?

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.

$$\vec{F}_{\text{(object causing force)}\rightarrow\text{(object feeling force)}}^{\text{type of force}}$$

Reading questions (forces)

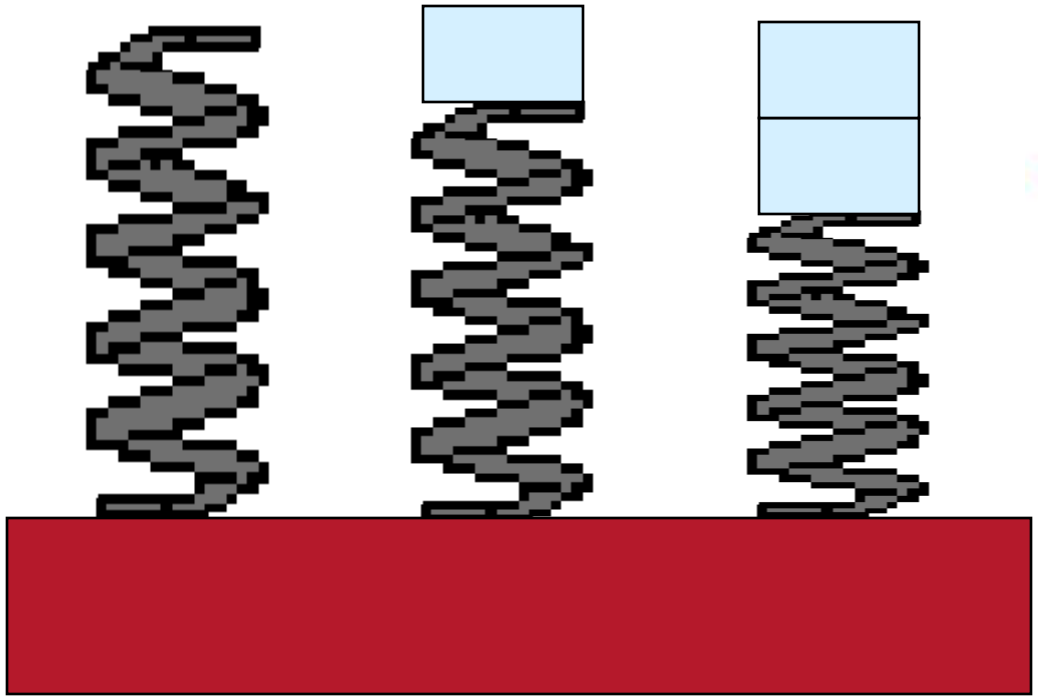
- Why are weight, electric forces, and magnetic forces called "non-touching" forces?
- Do these 6 forces account for all known forces?
- It is believed that when we touch something we aren't really touching the object, our atoms are just pushing the atoms in the object. If this is the case, would that mean that all normal forces are just electrical forces that we can actually see?
- If weight is a force why is it measured in kg and not N?
- What would centripetal force be classified as? Is it a touch or non-touch force? If it does not fit into any of the categories, then why was is it not mentioned in this section? What would it be classified as?
- Why exactly aren't weight and gravity considered the same forces?

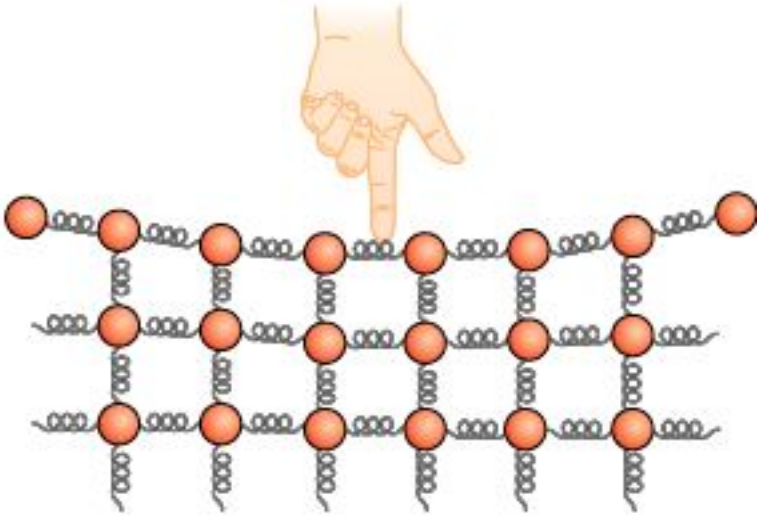
Tension:
The Spring

- A spring changes its length in response to pulls (or pushes) from opposite directions.

$$T = k\,\Delta l$$

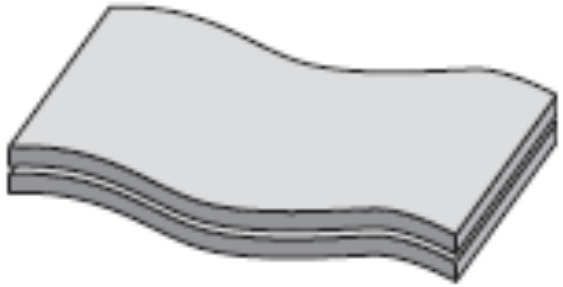
Normal Force:
works like a very stiff spring





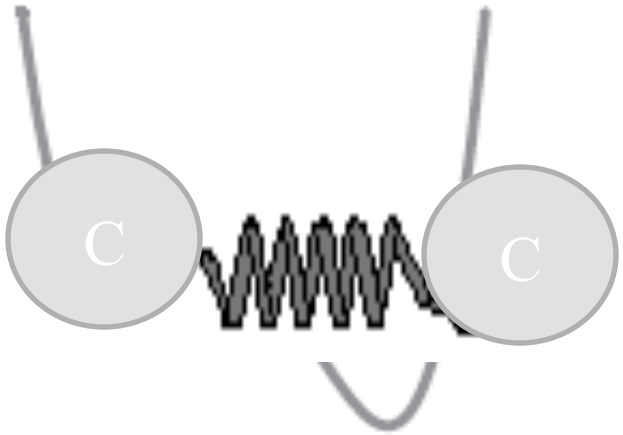
Springs in biology

DNA polymer wriggling in solution



cell membrane fluctuating

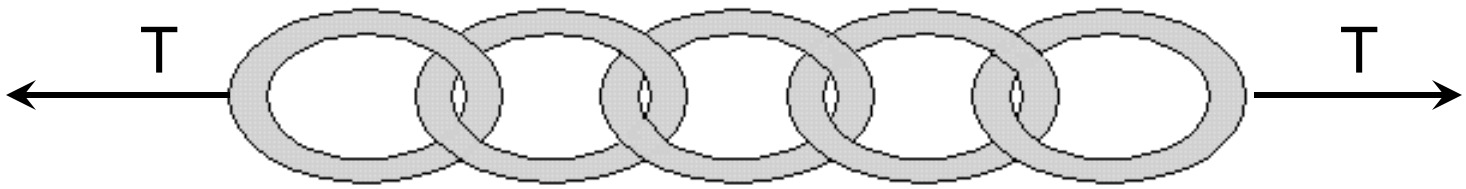
flagellum beating on a swimming sperm

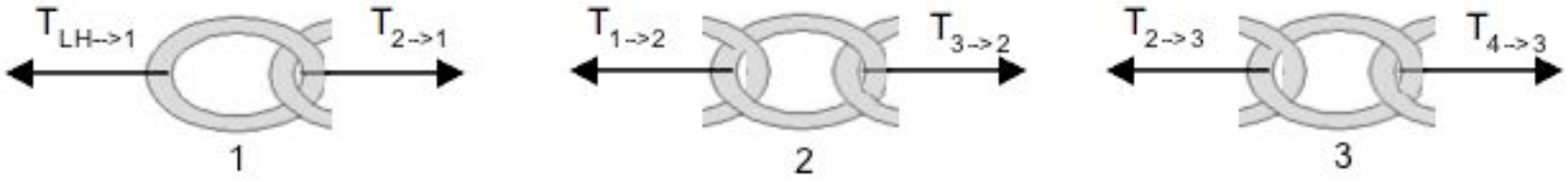


- Connected Atoms in molecules

Scalar vs. Vector Tension: The Chain

- Consider a series of links of chain being pulled from opposite directions. What are the forces on each link?





Tension: Scalar vs. Vector

- Note we are using the word "tension" in two distinct ways!
- The "tension" in a spring, chain, or string has no direction (or rather, both directions at once). It is a tension scalar.
- When tension appears at the end of a spring, chain, or string, the choice of end gives us a direction and lets us create a tension force.