Viscous Fluids
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- Viscosity is how engineers measure the resistance of fluids when being deformed:

\[ \tau = \mu \left( \frac{du}{dy} \right) \]

- The less viscous the fluid, the greater its ease of movement.

- Viscosity is useful for calculating the force needed to move a fluid. For example, in these industries:
  - petroleum
  - printing
  - food and beverages
Measuring Viscosity: Rheometer
Fluid Behavior: Newtonian

- Newtonian identified by
  - linear behavior
  - constant viscosity that is independent of velocity
- Slope is defined as the viscosity
- Examples:
  - water
  - gasoline
  - most gases
Fluid Behavior: shear thinning

- Shear thinning identified by: viscosity decreases as velocity increases
- Scientists do not fully understand what causes this phenomenon
- Examples:
  - ketchup
  - whipped cream
  - paint
  - motor oil
Fluid Behavior: shear thickening

- Shear thickening identified by: viscosity increases as velocity increases
- Due to closely packed particles that are combined with enough fluid to fill the space between them
- Examples:
  - body armor
  - viscous coupling unit (traction control)
  - cornstarch
Fluid Behavior: Bingham plastic

- Bingham plastic behaves as a solid at low stresses, but flows as a viscous fluid at high stresses.

- Due to particles in material having weak bonds that can be broken, allowing material to flow. Yet, when stress is gone, the bonds form again.

- Example:
  - toothpaste