What is a Fluid?
Solid Behavior - Deformation (ES 230)

So, a fluid is a substance that deforms without bound when subjected to shear, i.e. it “flows”: water, air, honey, beer, etc.

Fluid Behavior - Flow

\[ \tau = \text{shear modulus} \]

\[ \mu = \text{viscosity (resistance to flow)} \]

\[ \frac{d\theta}{dt} \] the Rate of angular def
Applications of fluid mechanics

- water supply, pipelines, conveyance systems
- stormwater management
- hydromachinery (pumps, turbines, propellers)
- groundwater & wells
- weather prediction, windpower, aerodynamics
- medicine (blood flow)

A practical application:

Forces on Vehicles Crossing Streams

The car will float downstream when:

Stream Force > Friction Force

\[ N = W - F_b \]

\[ F_f = \mu N \]

\[ D = C_d \rho V^2 A \]

Source: Steve Waters—Senior Hydrologist, Maricopa County Arizona Flood Control District
on to some important concepts in Chapter 1
THE FLUID AS A CONTINUUM

- We don’t care too much what the individual molecules are up to, we’ll look at lots of them together - thus, the fluid as a CONTINUOUS medium

DIMENSIONS

- “Dimensional Homogeneity”
- Equations derived from fundamental principles of math and physics must have the same dimensions (M, L, t, T) on both sides of the =

\[
\frac{p + z + \frac{V^2}{2g}}{\gamma} = \text{constant}
\]

\[
C_f = \frac{0.523}{\ln^2(0.06 \text{Re}_L)} - \frac{1520}{\text{Re}_L}
\]
DIMENSIONS

Table 1.2 PRIMARY DIMENSIONS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Symbol</th>
<th>Unit (SI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>$L$</td>
<td>meter (m)</td>
</tr>
<tr>
<td>Mass</td>
<td>$M$</td>
<td>kilogram (kg)</td>
</tr>
<tr>
<td>Time</td>
<td>$T$</td>
<td>second (s)</td>
</tr>
<tr>
<td>Temperature</td>
<td>$\theta$</td>
<td>kelvin (K)</td>
</tr>
<tr>
<td>Electric current</td>
<td>$i$</td>
<td>ampere (A)</td>
</tr>
<tr>
<td>Amount of light</td>
<td>$C'$</td>
<td>candela (cd)</td>
</tr>
<tr>
<td>Amount of matter</td>
<td>$N$</td>
<td>mole (mol)</td>
</tr>
</tbody>
</table>

1. Don't switch units (e.g., English to SI)
2. Carry units through calculations, don't add what you *think* the units should be at the end

EX: a 55-gal drum of water weighs what?

\[
55 \text{ gal} \times \frac{\text{ft}^3}{7.48 \text{ gal}} \times 62.4 \text{ lbs/ft}^3 = 458.8 \text{ lbs}
\]

3. Check your units at the end to see that they make sense!
Components of Fluid Mechanics

1) *Hydrostatics* - distributed loads on submerged objects due to static water pressures

2) *Hydrodynamics* - theoretical, mathematical equations of fluid flow
   - theorists: Newton, Bernoulli

3) *Hydraulics* - empirical (experimental) measurements of fluids, fitted to mathematical functions
   - experimentalists: Da Vinci, Reynolds, Nikuradse, Froude