Chemical Engineering 374

Fluid Mechanics

Pressure and Fluid Statics

Spiritual Thought

D&C 98:23-30

23 Now, I speak unto you concerning your families—if men will smite you, or your families, **once**, and ye bear it patiently and revile not against them, neither seek revenge, ye shall be rewarded;

25 And again, if your enemy shall smite you the **second** time, and you revile not against your enemy, and bear it patiently, your reward shall be an **hundred-fold**.

26 And again, if he shall smite you the **third** time, and ye bear it patiently, your reward shall be **doubled unto you four-fold**;

29 And then, if he shall come upon you or your children, or your children's children unto the third and fourth generation, I have delivered thine enemy into thine hands;

30 And then if thou wilt spare him, thou shalt be rewarded for thy righteousness; and **also thy children and thy children's children unto the third and fourth generation**.

OEP #2 (clip)

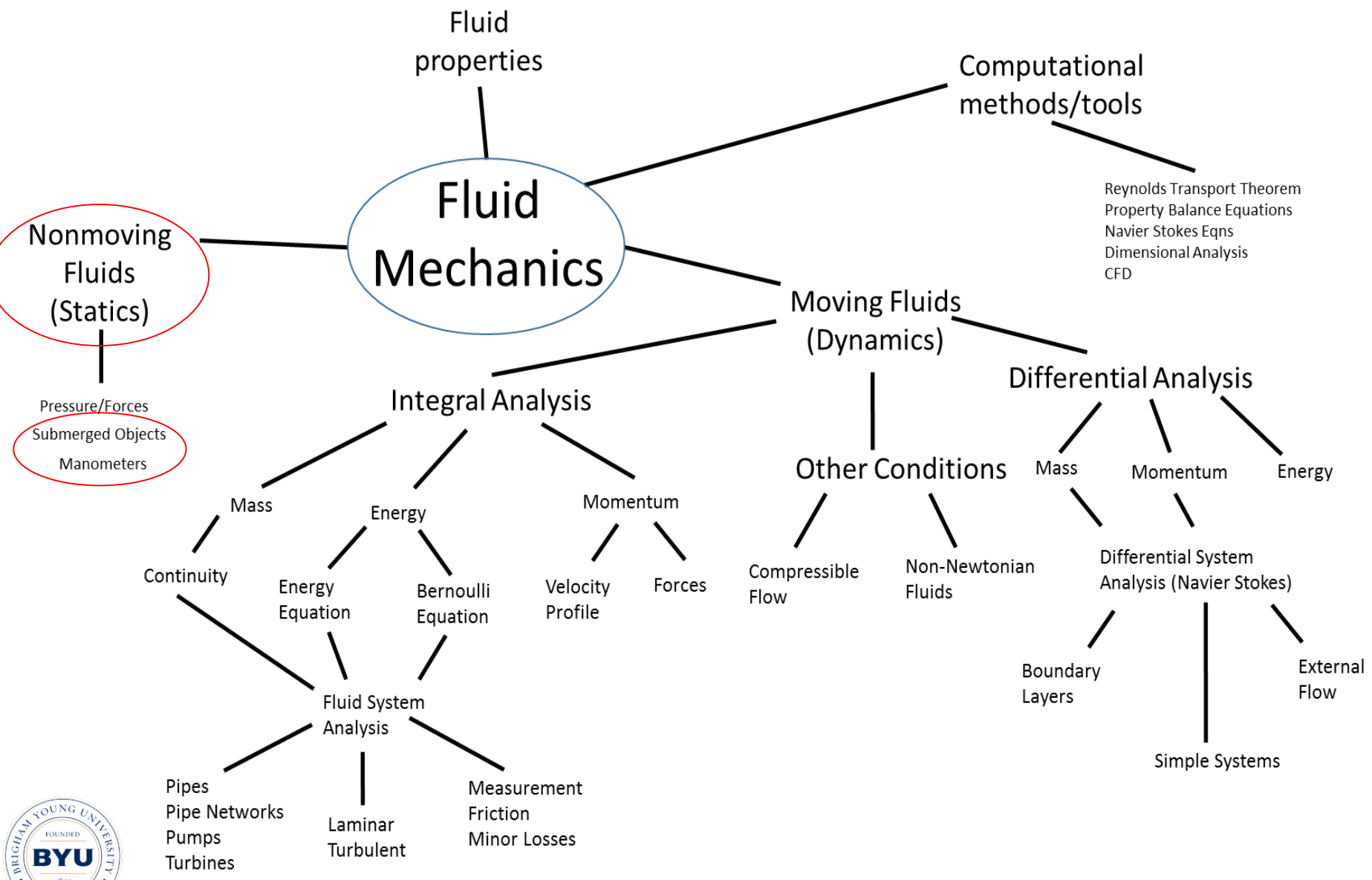
OEP #2

Open Ended Problem #2
Planet Naboo's Watery Core
Individual work only, Due 9/16/15 at beginning of class
(Don't be afraid to "Google" good assumptions!)

Star Wars Episode 1 Clip

Master Jin and Obi-Wan need to find and take the fastest way from the Gungan city in the ocean to the Naboo capital, but there is significant danger in taking this path. One obvious risk is being eaten by massive sea creatures. An additional risk is being crushed by the hydrostatic pressure of the oceans. Neglecting the teeth/jaws of the predators, at what point(s) do the Jedi (and Jar-Jar) run the greatest risk of being crushed, and how significant is that risk?

Fluids Roadmap



Key Points

- Buoyancy
  - Statics, Force Balance
- Pressure Measurement
  - Barometer
  - Bordon Tube
  - Manometer
  - Others
- Surface forces on submerged objects

Buoyancy

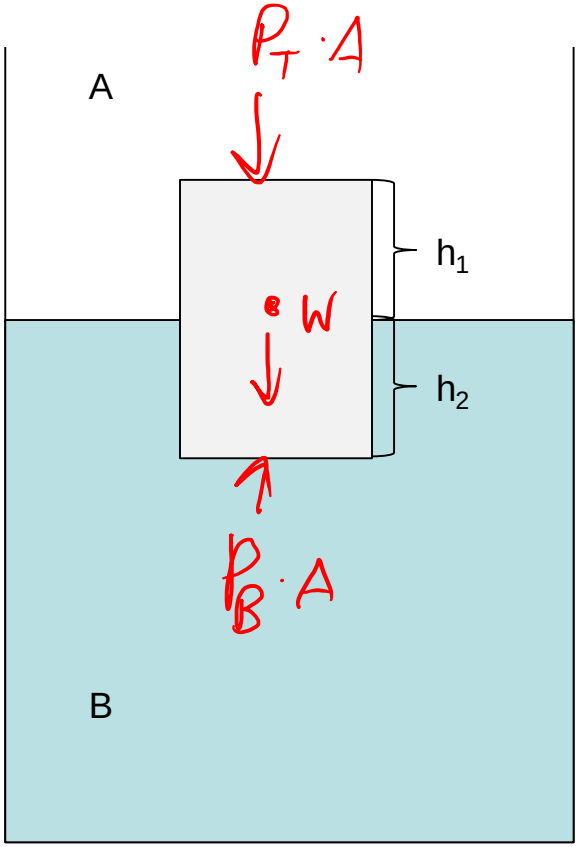
Analysis

- Force Balance? $\Sigma F = 0$ 3 Forces

  W, Bottom Pressure, Top Pressure

  $0 = P_B \cdot A - P_T \cdot A - W$

  $\therefore W = P_B \cdot A - P_T \cdot A$



- Bottom Pressure?

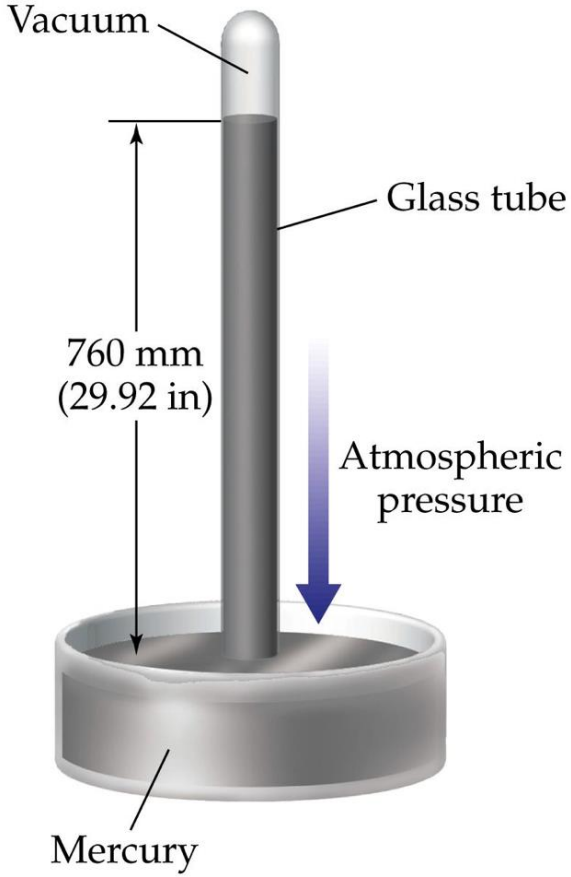
  $P_B = P_T + \rho_A g h_1 + \rho_B g h_2$

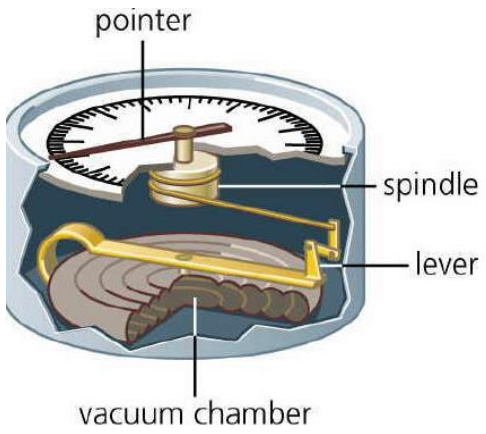
- Force of Buoyancy?

  $W = F_B = \cancel{P_T A} + \rho_A g h_1 A + \rho_B g h_2 A - \cancel{P_T A}$

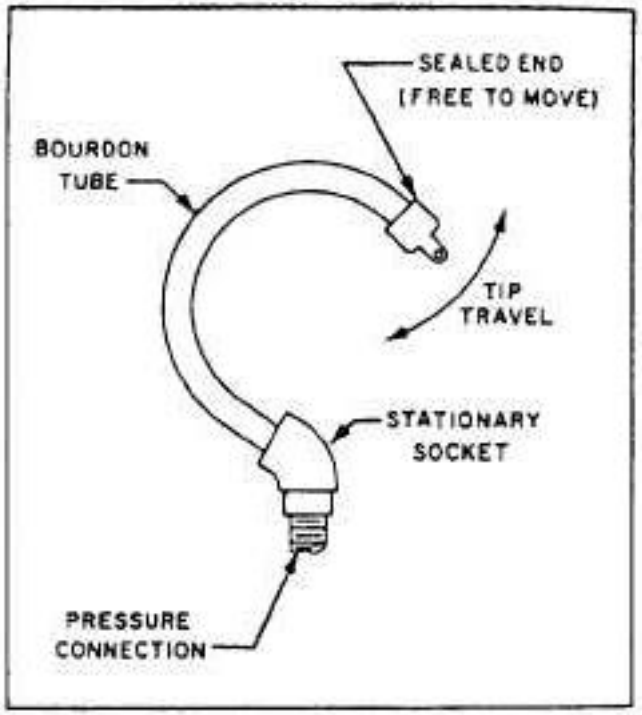
  $F_B = \rho_A g h_1 A + \rho_B g h_2 A \Rightarrow$ weight of displaced fluid (A & B)

Barometer


Vacuum
Glass tube
760 mm
(29.92 in)
Atmospheric
pressure
Mercury


pointer
spindle
lever
vacuum chamber

Bourdon Tube

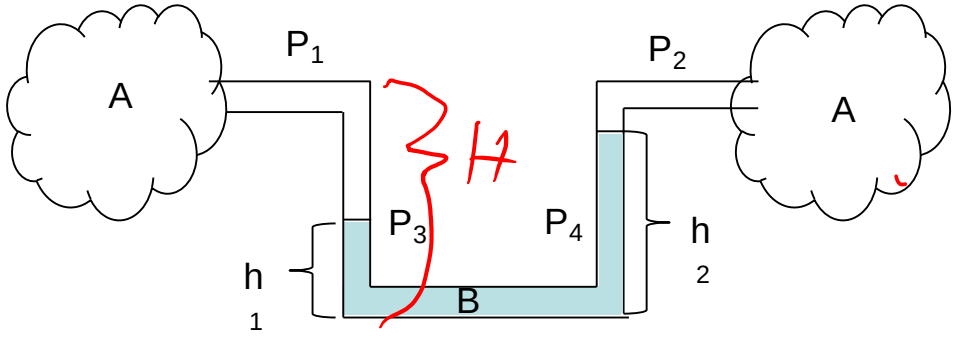


Bourdon Tube Demonstration

Bourdon Tube Gauge

Manometers

- Common in Labs
  - Fluid column → measure ΔP
  - Works for small to medium ΔP



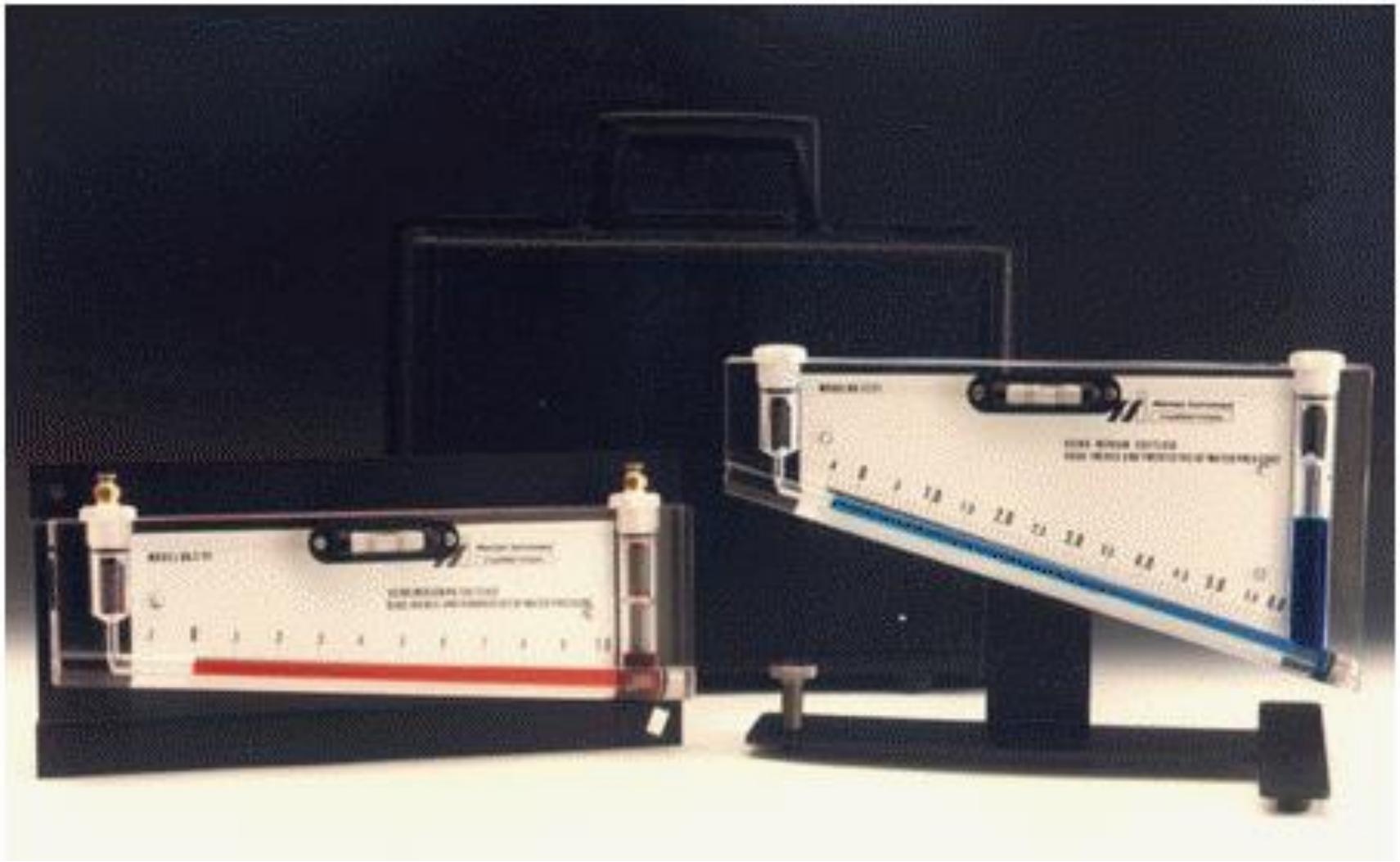
If A is gas, then $\Delta P = \rho_B g (h_2 - h_1)$

Know pressure at P_1 → what is pressure at B?

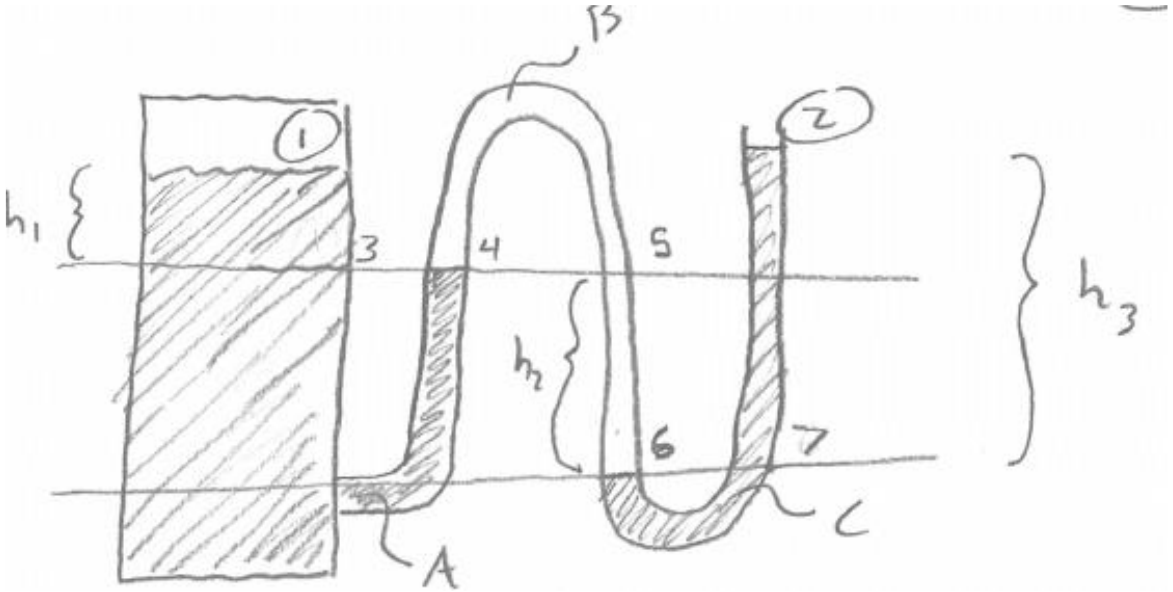
$$P_1 + \rho_A g(H - h_1) + \rho_B g h_1 - \rho_B g h_2 - \rho_A g(H - h_2) = P_2$$

$$P_2 - P_1 = (\rho_B - \rho_A) g (h_2 - h_1) \Rightarrow \Delta P = \Delta\rho g \Delta h$$

Manometer



Manometer Example



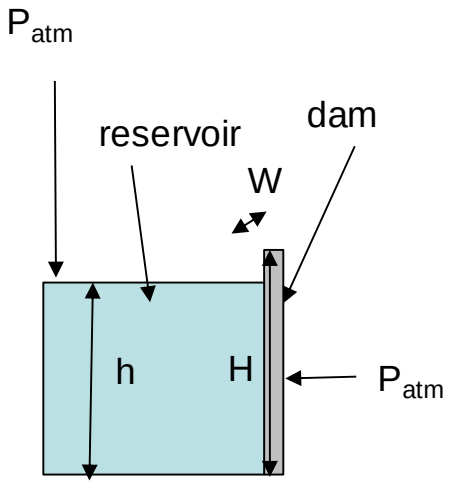
$$P_2 = P_1 + \rho_A g h_1 + \rho_B g h_2 + \rho_C g h_3$$

1→3 5→6 7→2

3=5 hop 6=7 hop

Forces on Surfaces

- Pressure vs. height?
- F = P*A
  - dF = PdA
  - dF = (P)W*dh
  - P = ρgh
  - Atm → both sides



Insights:

- F = $F = \frac{\rho g W H^2}{2} = \left(\rho g \frac{H}{2}\right)(HW)$
- Or P force evaluated at h=H/2
  - Linear pressure increase
  - Avg = half of line = H/2
  - Centroid = Area-Weighted Avg. Height
- Where does force act?
  - Center of pressure
- For rectangle, H/2 still; other shapes, centroid in book