let $p_2 = p_0$ (pressure at 0 depth)

let $h = y_2 - y_1$ (height of water above depth $h$)

This gives $p = p_0 + \rho g h$

What is pressure at 100m below sea?

$$p = p_{atm} + \left(1.03 \tfrac{g}{cm^3}\right)\left(9.8\, m/s^2\right)(100m)$$

$$p = \underbrace{\underbrace{1.013 \times 10^5\, Pa}_{1\ atm} + \underbrace{1.010 \times 10^6\, Pa}_{\approx 10\ atm}}$$

gauge pressure
→ pressure above atmospheric pressure

absolute pressure
→ total pressure

# Pascal's Law



$$p = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_2 = \frac{A_2}{A_1} F_1$$ force has been multiplied by ratio of areas.

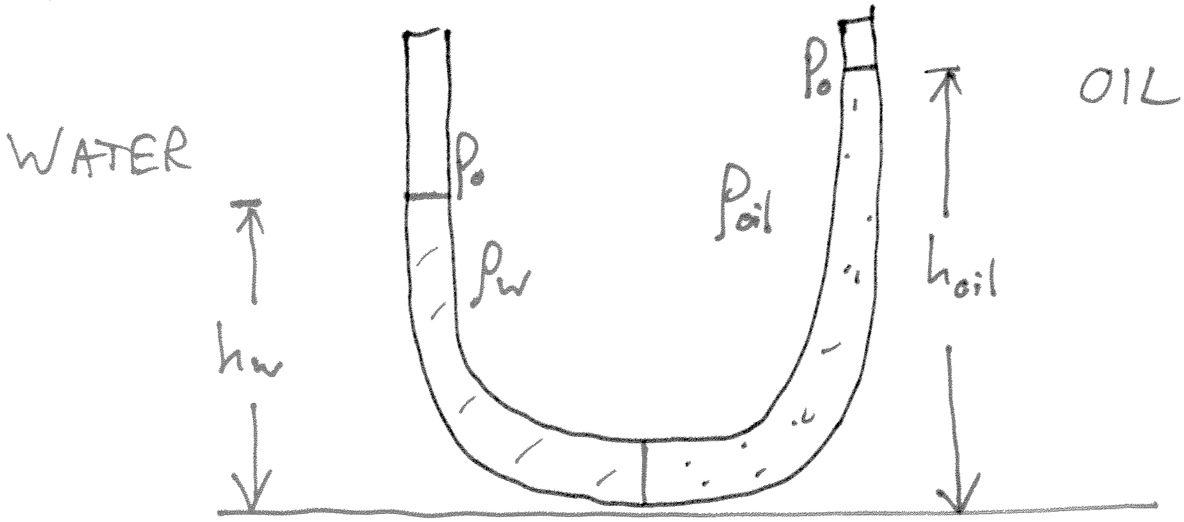
Principle ~~behind~~ behind hydraulics.

<u>Figure</u> 12.8 a) $p = p_{atm} + \rho g h$

b) $p_{atm} = \rho g h$

# Example 12.4






What is more dense?

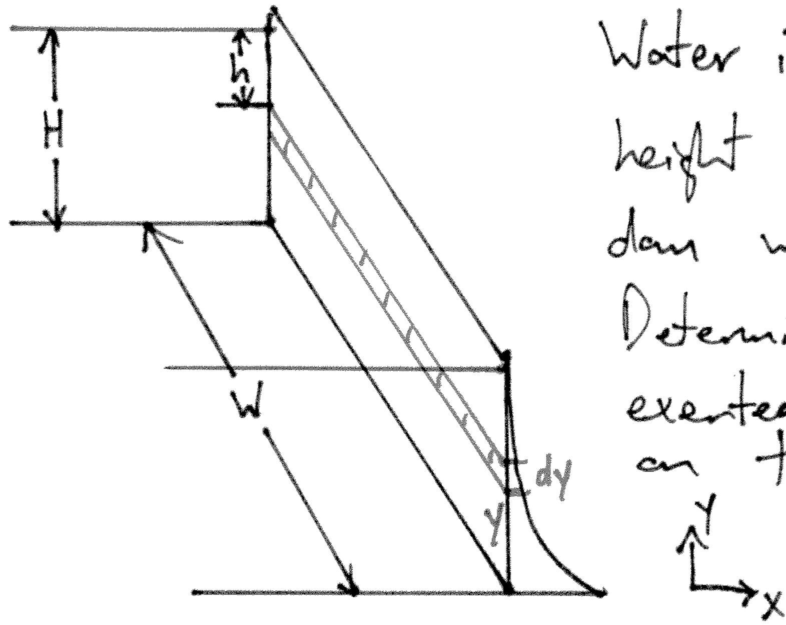
$$\underline{\rho_{oil} < \rho_{water}}$$

Express $h_{oil}$ in terms of all other variables.

$$p = p_0 + \rho_w h_w g \qquad \rho_w h_w g$$

$$p = p_0 + \rho_{oil} h_{oil} g$$

$$h_{oil} = \frac{\rho_{water}}{\rho_{oil}} h_{water}$$




Water is filled to a height H behind a dam with width w. Determine the force exerted by the water on the dam.

- pressure varies with depth, cannot calculate force simply by multiplying by area

variation } integrate
total force }

pressure due to water only at depth h

$$P = \rho g h = \rho g (H - y)$$

$$dF = p\,dA = \rho g (H-y) w\,dy \quad (dA = w\,dy)$$

$$F = \int p\,dA = \int_0^H \rho g (H-y) w\,dy$$

$$= \frac{1}{2} \rho g w H^2$$

# 12.5 Bernoulli's Equation

When an incompressible fluid flows along a flow tube with varying cross section, its speed must change, and so an element of fluid must have an acceleration

↳ This comes from change in pressure

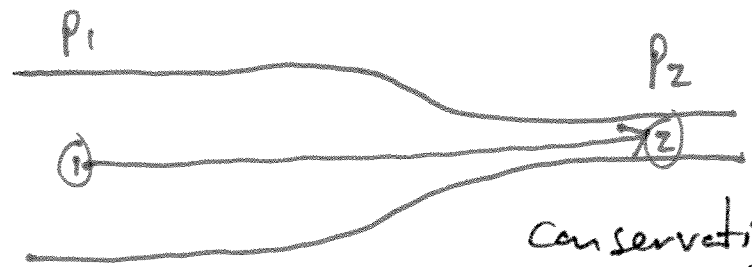
derivation p. 385 - 386

for everywhere along flow

$$p + \rho g y + \frac{1}{2}\rho v^2 = \text{constant}$$

so for any 2 points along flow

$$p_1 + \cancel{\rho g y_1} + \frac{1}{2}\rho v_1^2 = p_2 + \cancel{\rho g y_2} + \frac{1}{2}\rho v_2^2$$




conservation of volume, flow velocity must be greater at 2

$$v_1 A_1 = v_2 A_2$$

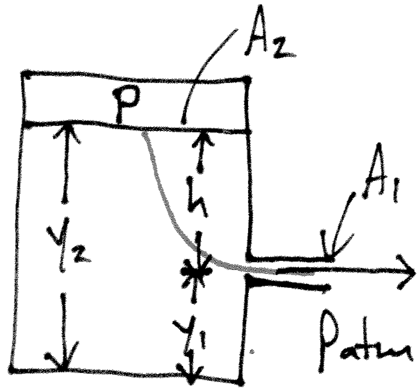
- $p_2 < p_1$

Solve for $v_2$

$$p_1 + \frac{1}{2}\rho\left(\frac{A_2}{A_1}\right)^2 v_2^2 = p_2 + \frac{1}{2}\rho v_2^2$$

$$v_2 = A_1\sqrt{\frac{2(p_1 - p_2)}{\rho(A_1^2 - A_2^2)}}$$

FIRE EXTINGUISHER (pressurized tank)




What is $v_1$?

$$p + \rho g y_2 + \cancel{\frac{1}{2}\rho v_2^2} = p_{atm} + \rho g y_1 + \frac{1}{2}\rho v_1^2$$

assume $A_2 \gg A_1$

$$v_1 A_1 = v_2 A_2$$

$$v_2 = \frac{A_1}{A_2} v_1 \to 0$$

$$v_2 = 0$$

$$v_1 = \sqrt{\frac{2(p - p_0)}{\rho} + 2gh} \qquad y_2 - y_1 = h$$

Open up top of container

$$P_{atm} + \rho g y_2 = P_{atm} + \rho g y_1 + \frac{1}{2}\rho v_1^2$$

$$g(y_2 - y_1) = \frac{1}{2} v_1^2$$

$$\boxed{v_1 = \sqrt{2gh}}$$

Torricelli's Law

speed of object falling freely a distance of h