- **Theme Music: Queen**

  Under Pressure

- **Cartoon: Bill Watterson**

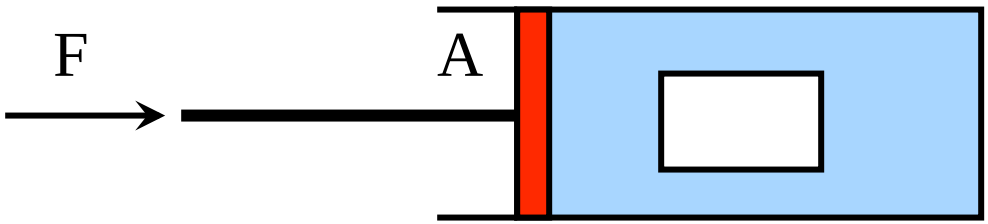
  Calvin & Hobbes

Outline

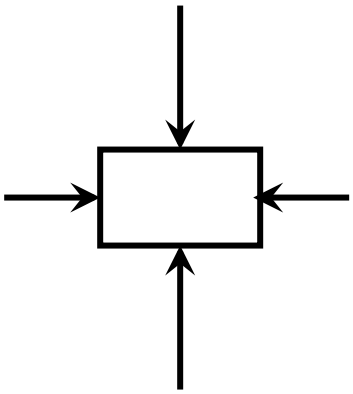
- Quiz 9: Torque and rotational energy
- Fluids
  - Pressure
  - Fluids under gravity
- Archimedes' Principle

Pressure

- What forces are exerted on the box imbedded in the fluid?



Pressure has no direction! It acts in all directions at once!



$$p = \frac{F}{A}$$

$$\vec{F} = p\vec{A}$$

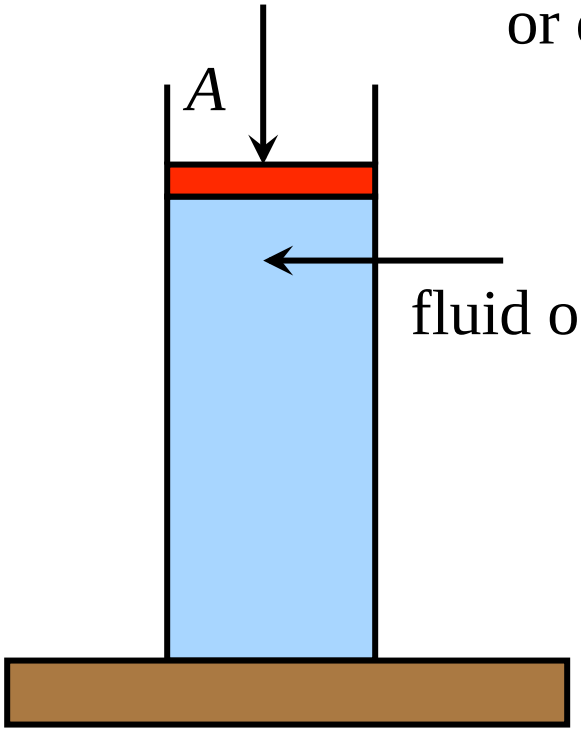
The force takes its direction from A.

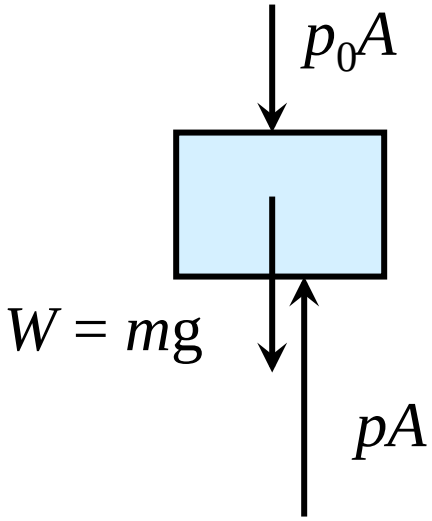
Drawing on experience

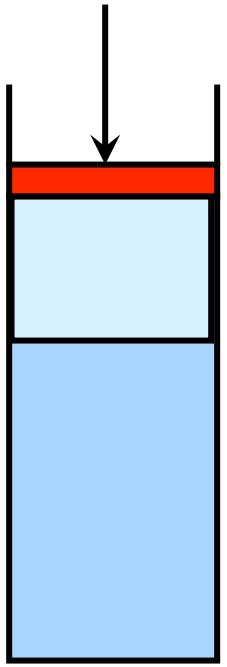
- What happens when an object is immersed in a fluid?
- Examples?

Fluids in Gravity

$F = p_0 A$ (could be outside air pressure or due to external weights)







Variation of Pressure with Depth*

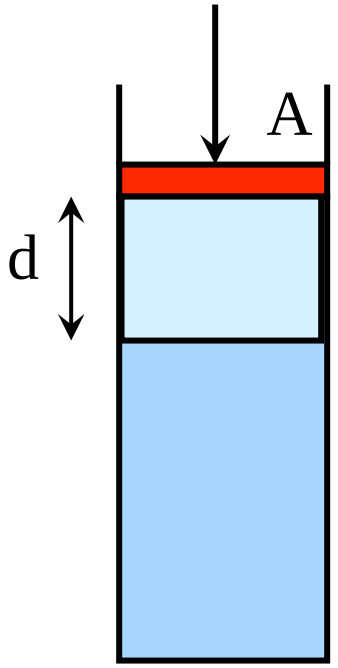
$$F^{down} = F^{up}$$

$$mg + p_0 A = pA$$

$$\rho V g + p_0 A = pA$$

$$\rho A d g + p_0 A = pA$$

$$p = p_0 + \rho g d$$



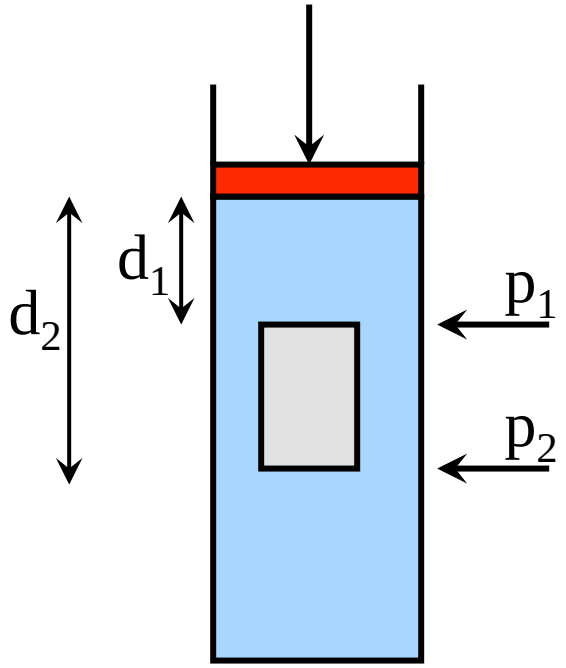
* We assumed uniform density. Is this OK?

For water ($\rho \sim 1000$ kg/m^3) yes.

For air ($\rho \sim 1$ kg/m^3) OK for meters — not km.

Archimedes' Principle: 1

- What happens when an object is immersed in a fluid?
- The pressure at the bottom is greater than the pressure at the top so overall the fluid pushes up.



Archimedes' Principle: 2

$$F^{net} = p_2 A - p_1 A$$

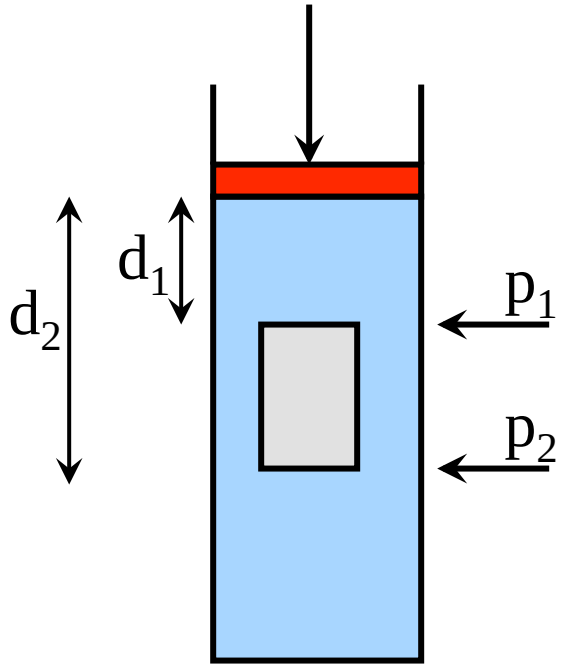
$$p_1 = p_0 + \rho g d_1$$

$$p_2 = p_0 + \rho g d_2$$

$$F^{net} = (p_2 - p_1) A$$

$$F^{net} = (p_0 + \rho g d_2 - p_0 - \rho g d_1) A$$

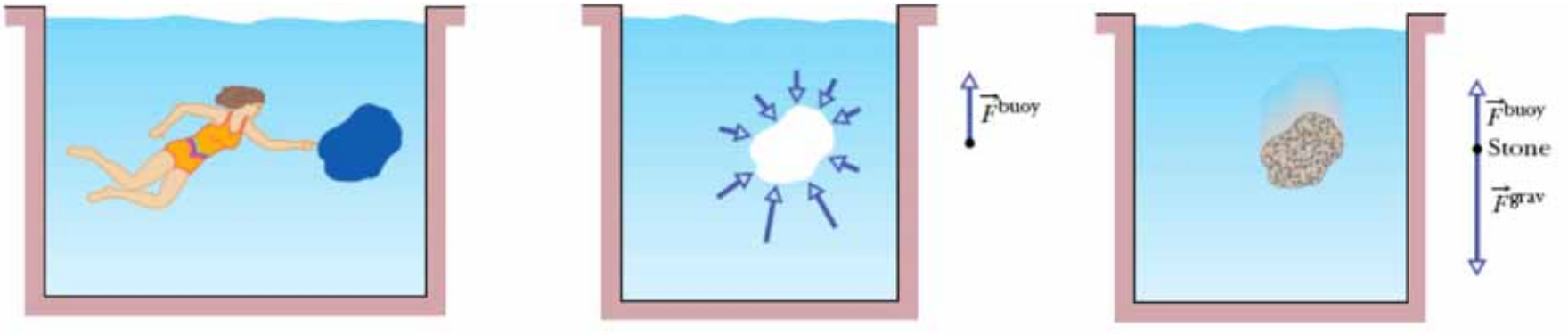
$$F^{net} = \rho g (d_2 - d_1) A = \rho V g = mg$$



The buoyant (upward) force = the weight of the fluid displaced.

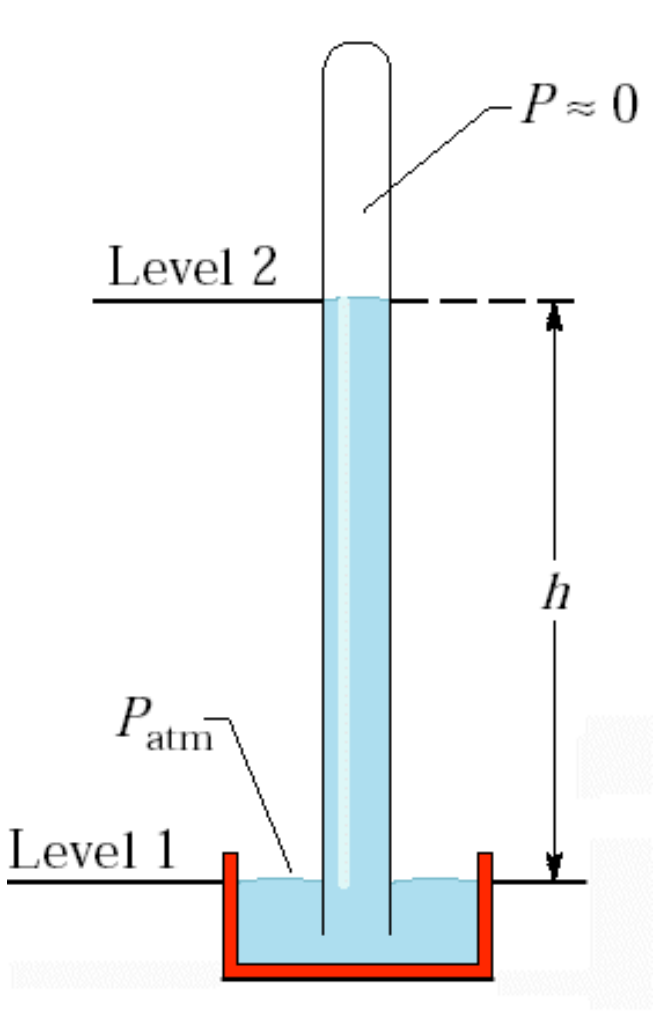
Making sense of AP

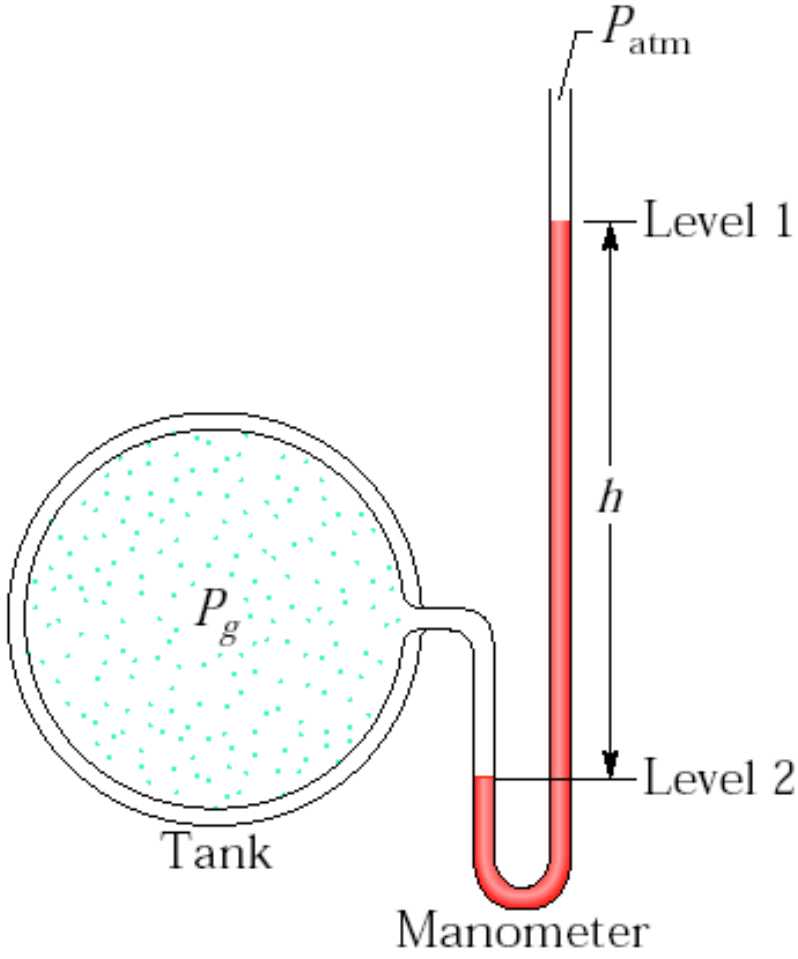
- Consider the forces on a bag of water the same shape as an immersed object.



- The BF is equal to the weight of the water displaced – that's what the surrounding water can hold up!

Measuring Pressure: Manometers





Measuring Pressure: Units

	Pascal (N/m^2)	atm	mm of Hg	millibar	lb/in^2
Pascal (N/m^2)	1	10^{-5}	7.5×10^{-5}	0.01	1.5×10^{-4}
atm	10^5	1	760	1000	14.7
mm of Hg			1		
millibar				1	
lb/in^2					1