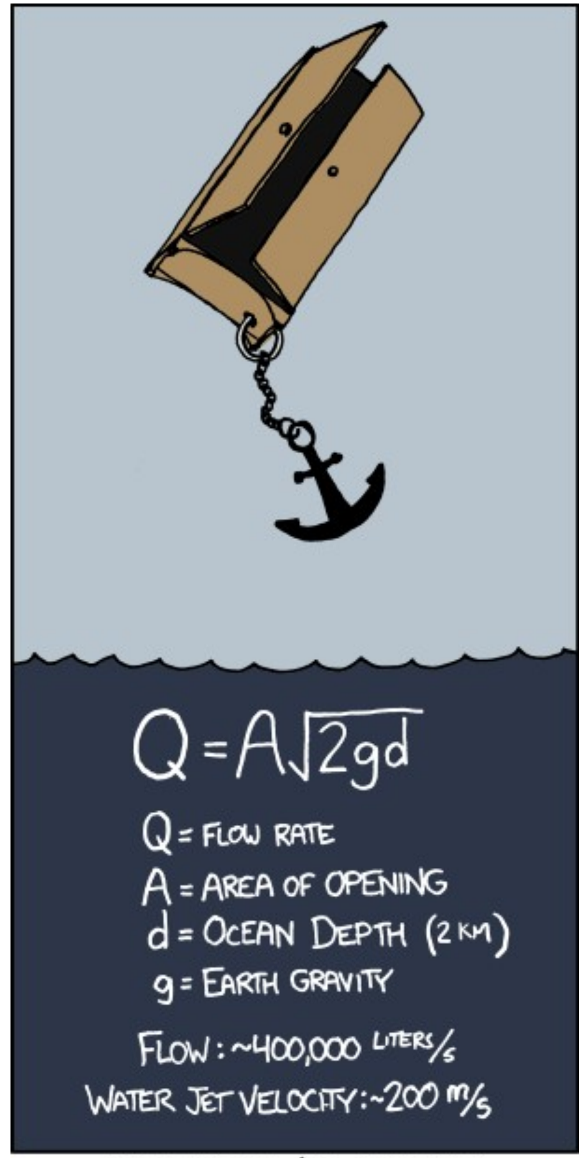
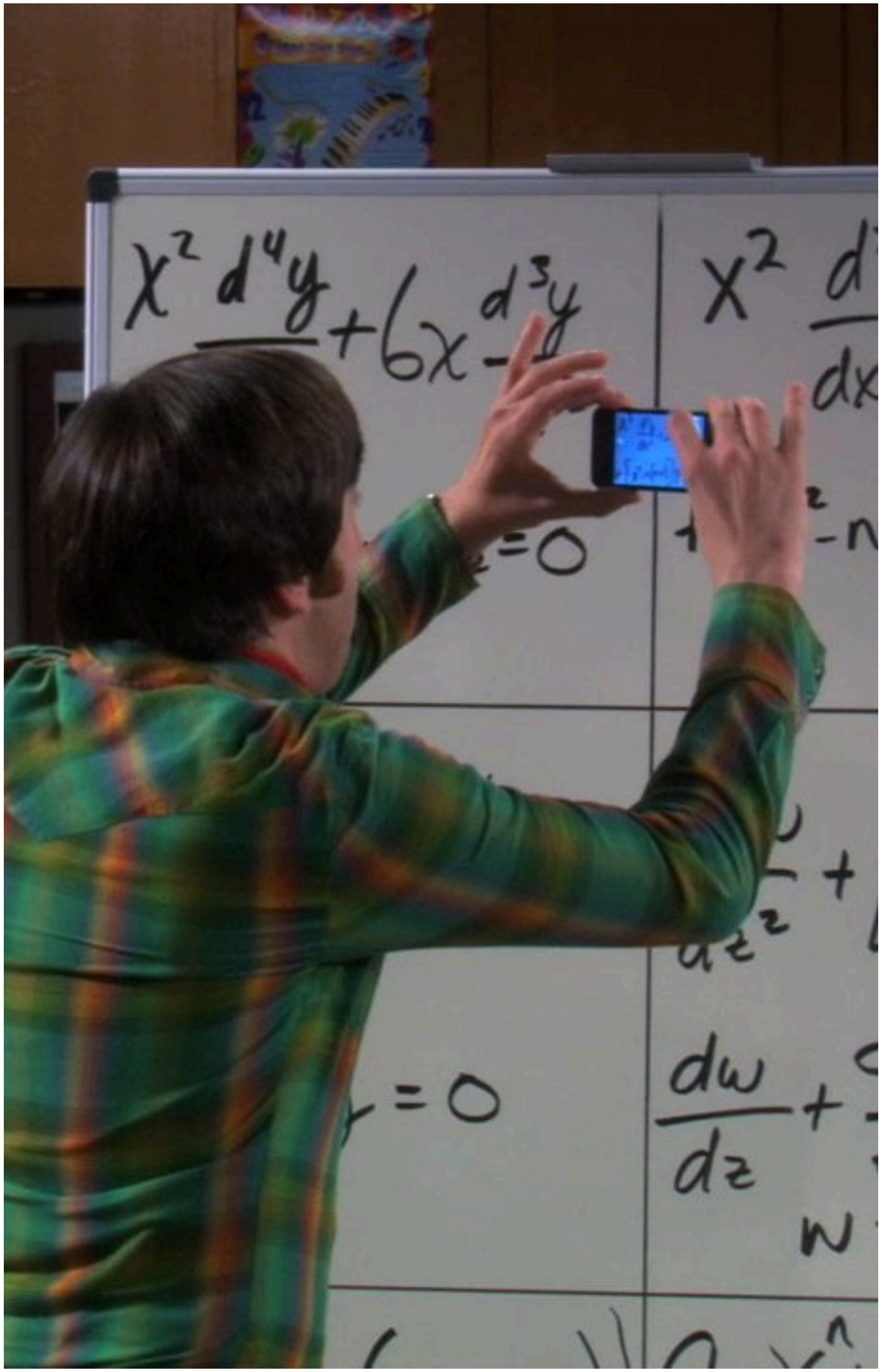
November 4, 2015 Physics 131 Prof. E. F. Redish

- **<u>Theme Music:</u>**
  Pearl Jam
  Even Flow

- **<u>Cartoon:</u>**
  Randall Munroe
  xkcd



THE WHITE WITCH DIDN'T KNOW WHAT HIT HER.



The Equation of the Day

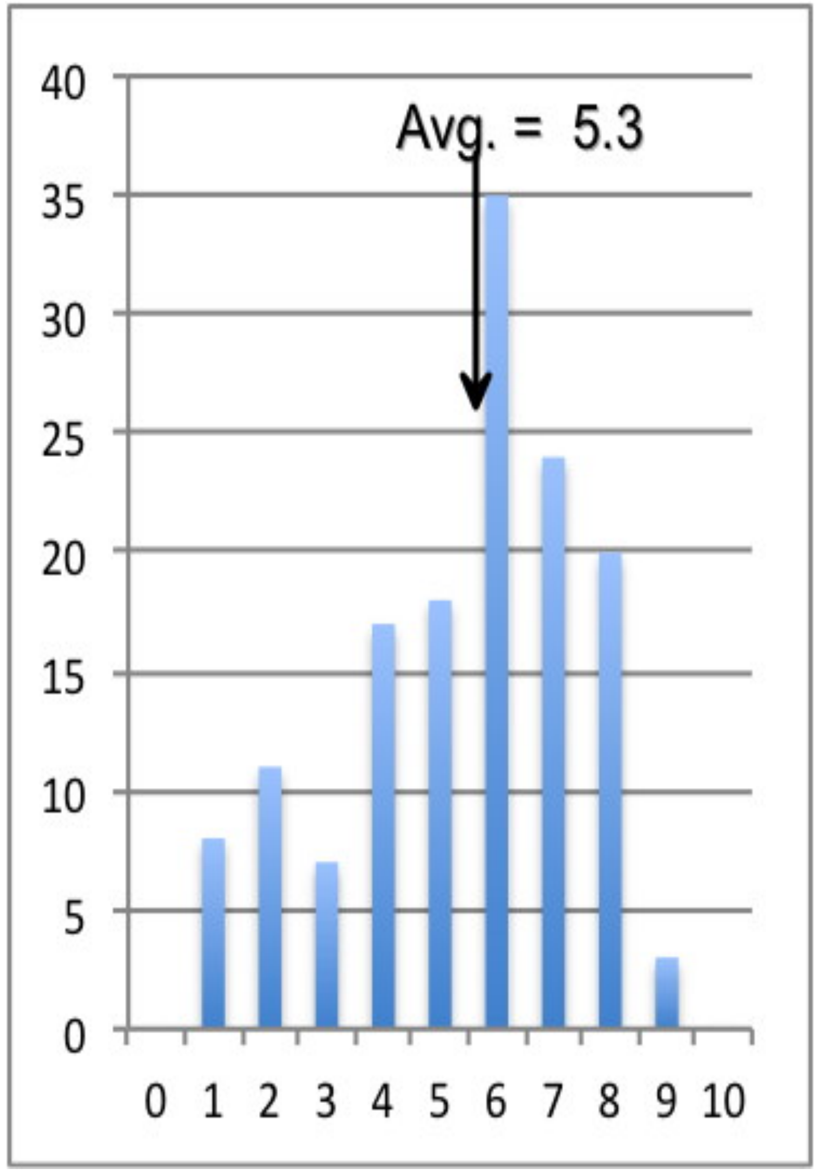
The Hagen-Poiseuille Equation

$$\Delta p = \left(\frac{8\mu L}{\pi R^4} \right) Q$$

Quiz 8

	1		2
M/T^2	**76%**	**γ/Δp**	**38%**
ML/T^2	2%	**γΔp**	6%
M/LT	1%	**Δp/γ**	41%
MT/L^2	1%	**Sqrt(γ/Δp)**	2%

	3		4
a>b>c>d	25%	**a**	2%
d>c>b>a	23%	**b**	54%
a=b=c=d	20%	**c**	**25%**
b=c=d>a	**1%**	**d**	**9%**
a>c>b>d	2%	**e**	1%
c>b>a>d	8%	**f**	9%
b=c>a>d	1%		
a>b=c>d	8%		



Foothold ideas: Surface tension

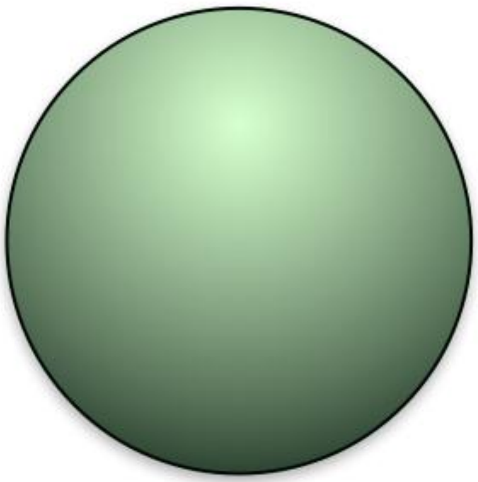
- Due to the intermolecular interactions holding a liquid together, the surface of a liquid experiences a tension.
- The pull across any line in the surface of the liquid is proportional to the length of the line.

$$F_{\text{surface tension}} = \gamma L$$

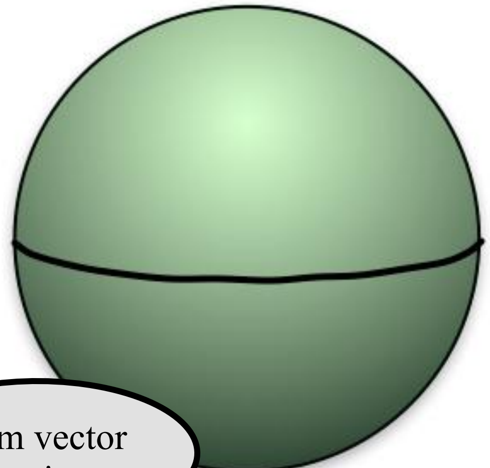
A bursting water balloon

Laplace Bubble Law

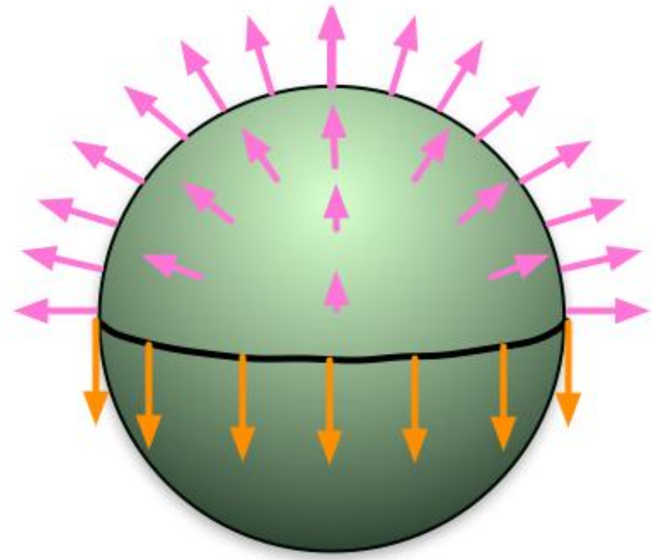
Consider a bubble



Now consider its top half



What forces act on it?



From vector averaging

$$F^{\uparrow}_{\text{air pressure inside}\to\text{top half}} = \tfrac{1}{2} pA = \tfrac{1}{2} p(2\pi r^2) = \pi p r^2$$

$$F^{\downarrow}_{\text{s.t. of bot half}\to\text{top half}} = \gamma L = \gamma(2\pi r) = 2\pi\gamma r$$

$$p = \frac{2\gamma}{r}$$

SMALLER bubble has bigger pressure!

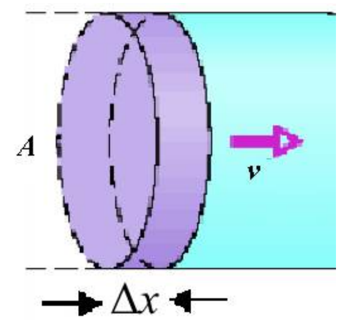
Force from pressure inside (up) must cancel pull of surface tension from the bottom half (down)

Foothold ideas: Matter Current (incompressible)

- Q = Current = (volume crossing a surface)/s

$$[Q] = \mathrm{m}^3/\mathrm{s}$$

$$\vec{Q} = \frac{\left(A\Delta\vec{x}\right)}{\Delta t} = \frac{\left(A\vec{v}\Delta t\right)}{\Delta t} = A\vec{v}$$

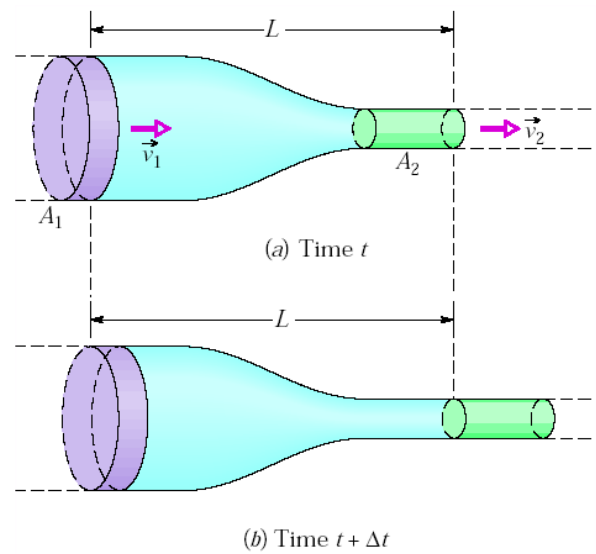


- Conservation of matter: "What goes in must come out."

$$\Delta V_{in} = \Delta V_{out}$$

$$A_1\left(v_1\Delta t\right) = A_2\left(v_2\Delta t\right)$$

$$Q = Av = \text{ constant}$$



Remember: Viscous Drag

- A fluid flowing in a pipe doesn't slip through the pipe frictionlessly.
- The fluid sticks to the walls moves faster at the middle of the pipe than at the edges.
  As a result, it has to "slide over itself" (shear).
- There is friction between layers of fluid moving at different speeds that creates a viscous drag force, trying to reduce the sliding.
- The drag is proportional to the speed and the length of pipe.

$$F_{drag} = 8\pi\mu Lv$$