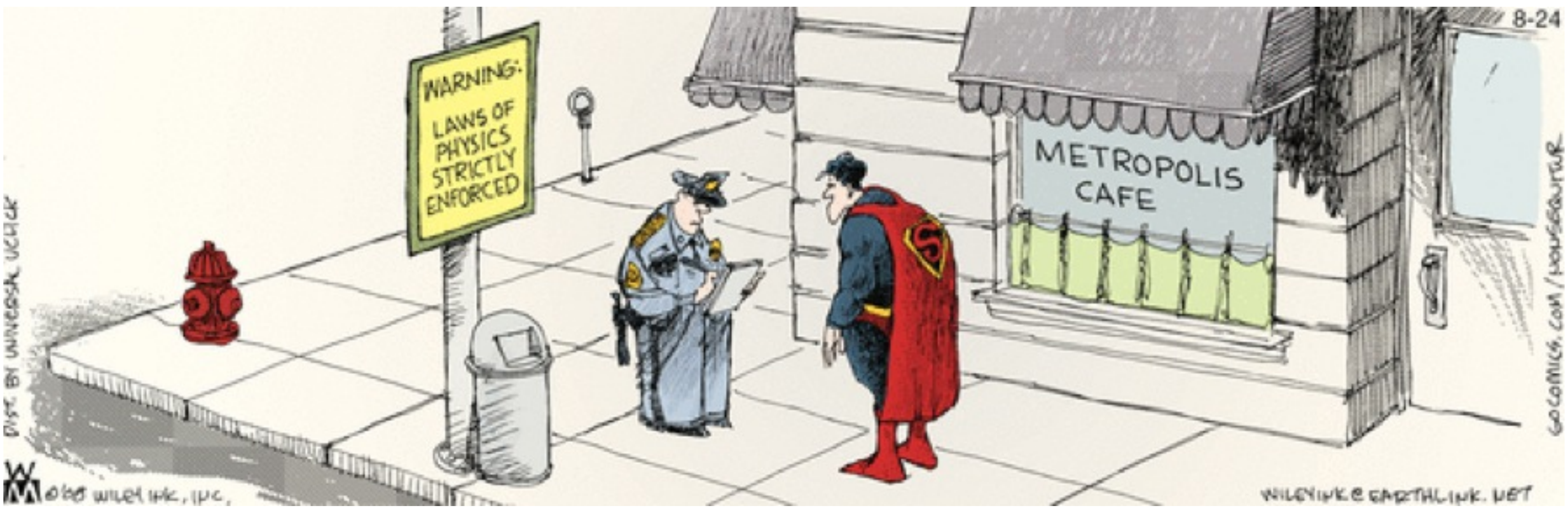
November 14, 2012 Physics 131 Prof. E. F. Redish

- **Theme Music:** **Sons of the Pioneers**

  Cool Water

- **Cartoon:** **Wiley Miller**

  Non-Sequitur

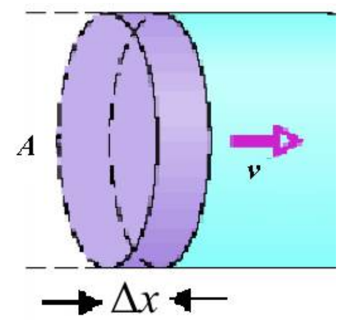


Foothold ideas: Matter Current (incompressible)

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

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

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

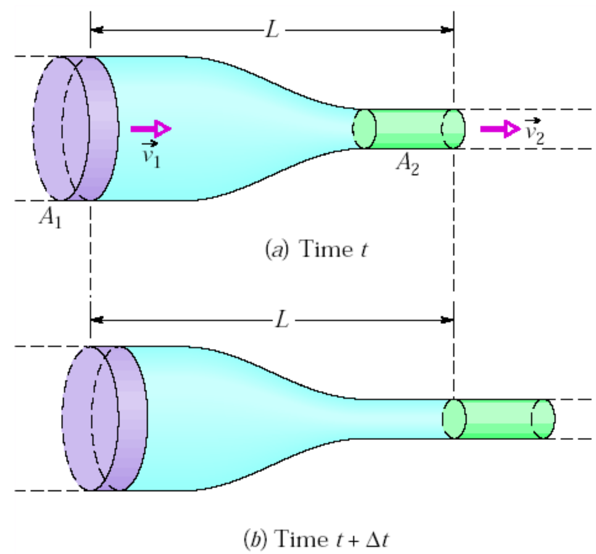


- Conservation of matter: "What goes in must come out."

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

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

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



Reading questions

- I am confused as to how flow rate increases with the fourth power of the tube radius. Intuition seems to say that if you have a larger tube than the flow will be lower since the pressure is lower. I can see from the equation why it makes sense, but I do not understand physically why it is this way.
- The reading says: " fluid keeps moving at a constant speed, the pressure must drop as we go downstream." I don't see why the pressure must go down as we move downstream. what makes the pressure different? For example in a hose when water is moving through, shouldn't the water have the same pressure throughout the whole tube?until the very end in which the water come out?

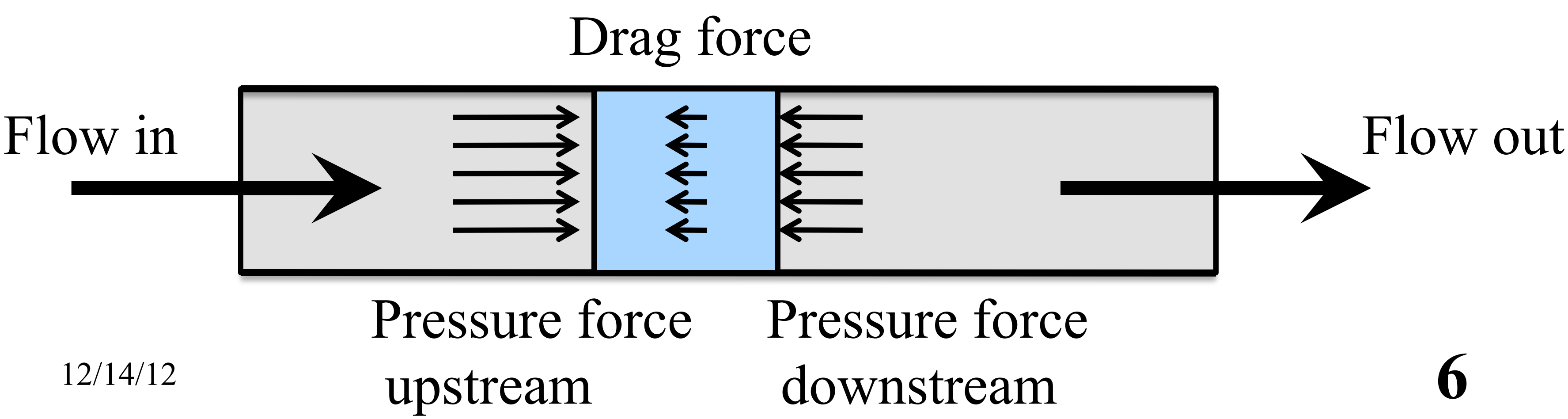
Viscous Drag

- 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.

$$F_{drag} = 8\pi\mu L v$$

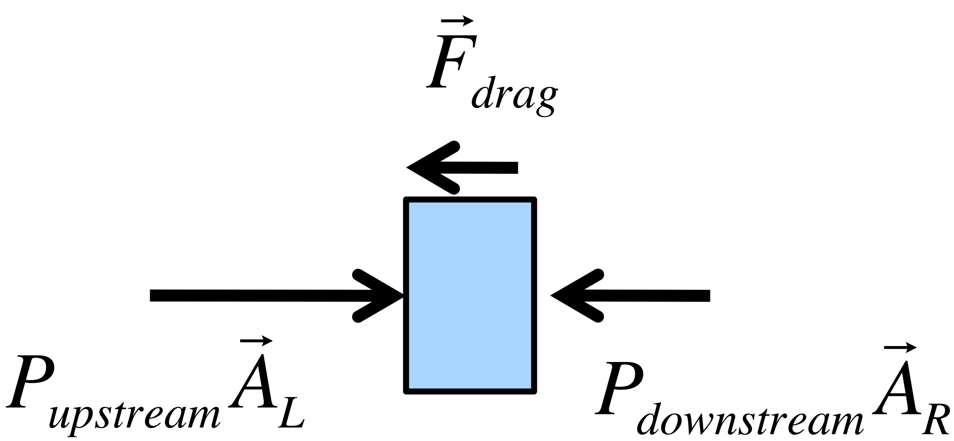
Implication: Pressure drop

- If we have a fluid moving at a constant rate and there is drag, N2 tells us there must be another force to balance the drag.
- The internal pressure in the fluid must drop in the direction of the flow to balance drag.



The Hagen-Poiseuille Law

- If the pressure drop balances the drag (and thereby maintains a constant flow) N2 tells us



$$\Delta P\, A = 8\pi\mu L v$$

$$\Delta P\, A = 8\pi\mu L\left(\frac{Q}{A}\right)$$

$$\Delta P = \left(\frac{8\pi\mu L}{A^2}\right)Q = \left(\frac{8\mu L}{\pi R^4}\right)Q$$

$$\Delta P = ZQ$$