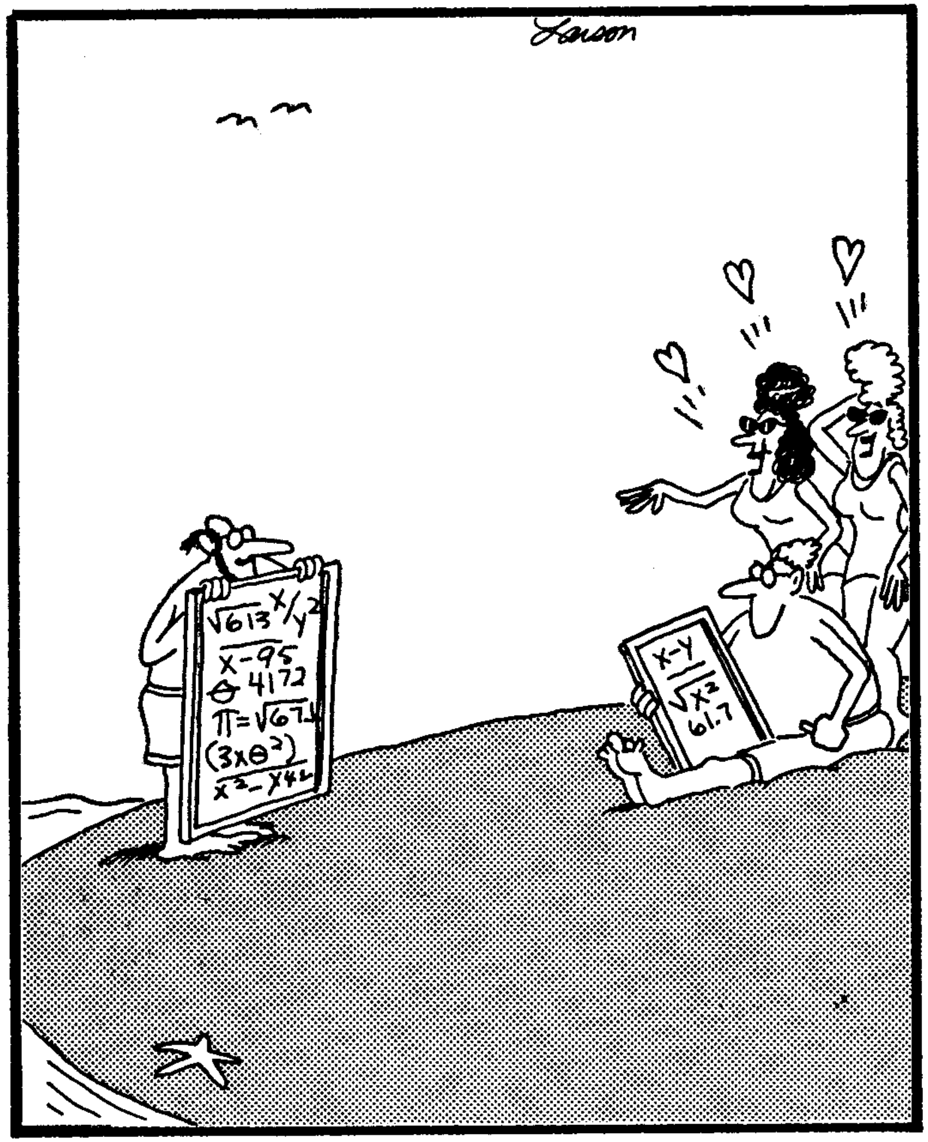
- **Theme Music:**
  Paul Simon
  The Cool, Cool River

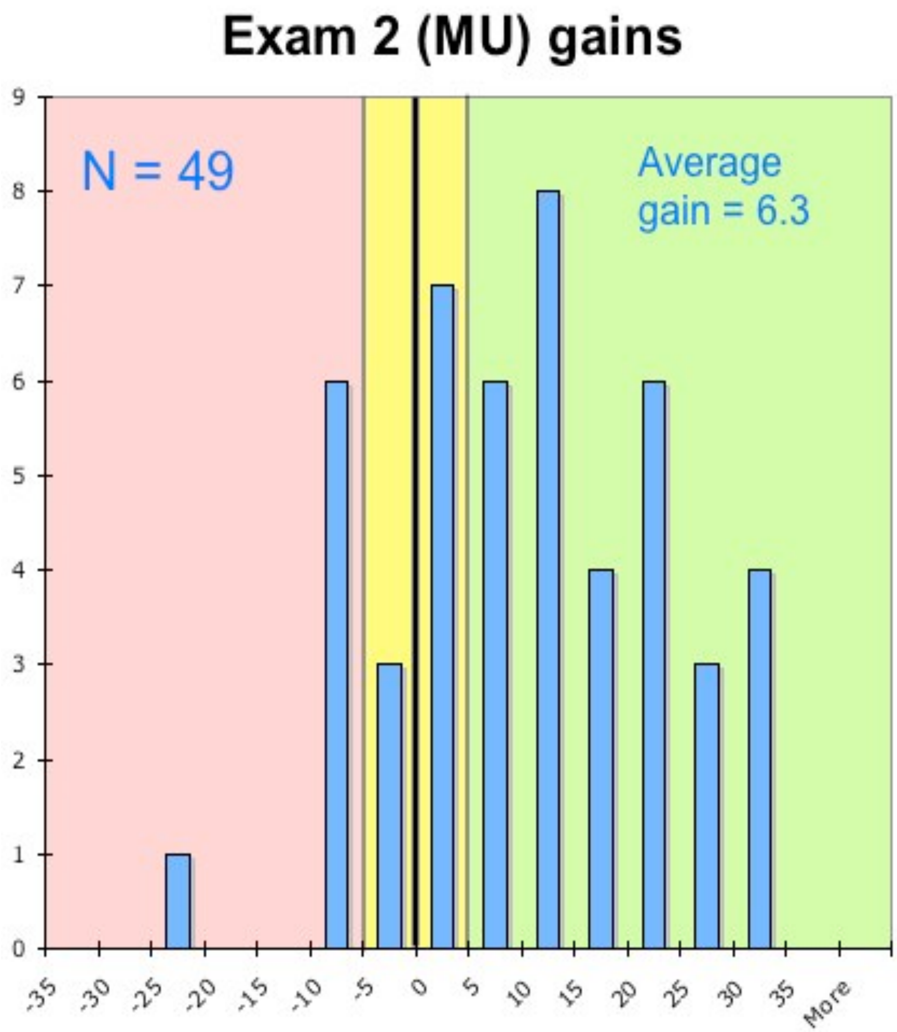
- **Cartoon:**
  Gary Larson
  The Far Side



Outline

- Results of makeup exam 2
- Pressure: Recap
  - Examples
- Fluid Flow
  - Implications of conservation of matter
  - Fluid friction: Viscous drag

Exam 2 Makeup



#1	#2	#3	#4	#5
65%	46%	63%	57%	50%

Some advice on getting the most points in problem solving

- Write the explicit principle you are going to use IN SYMBOLS.
- Write one sentence saying why it applies.
- Put relevant values in KEEPING UNITS.
- Perform the calculation KEEPING UNITS.
- Give your answer WITH UNITS and an appropriate number of significant figures.
- Look at your answer and see if the resulting numbers make sense. If not, say so.

Foothold ideas: Pressure

- A constrained fluid has an internal pressure –like an internal force at every point in all directions. (Pressure has no direction.)
- At a boundary or wall, the pressure creates a force perpendicular to the wall. $\vec{F} = p\vec{A}$
- The pressure in a fluid increases with depth. (Why?)

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

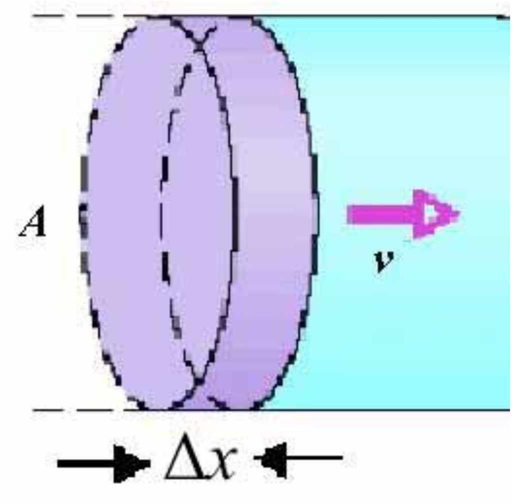
- When immersed in a fluid, an object feels an (upward) BF equal to the weight of the displaced fluid. (Archimedes' Principle)

Current (Volume Flow)

- Assume a fluid that is moving uniformly without changing density (compressing or expanding).
- Q = Current = (volume crossing a surface) / s

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

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



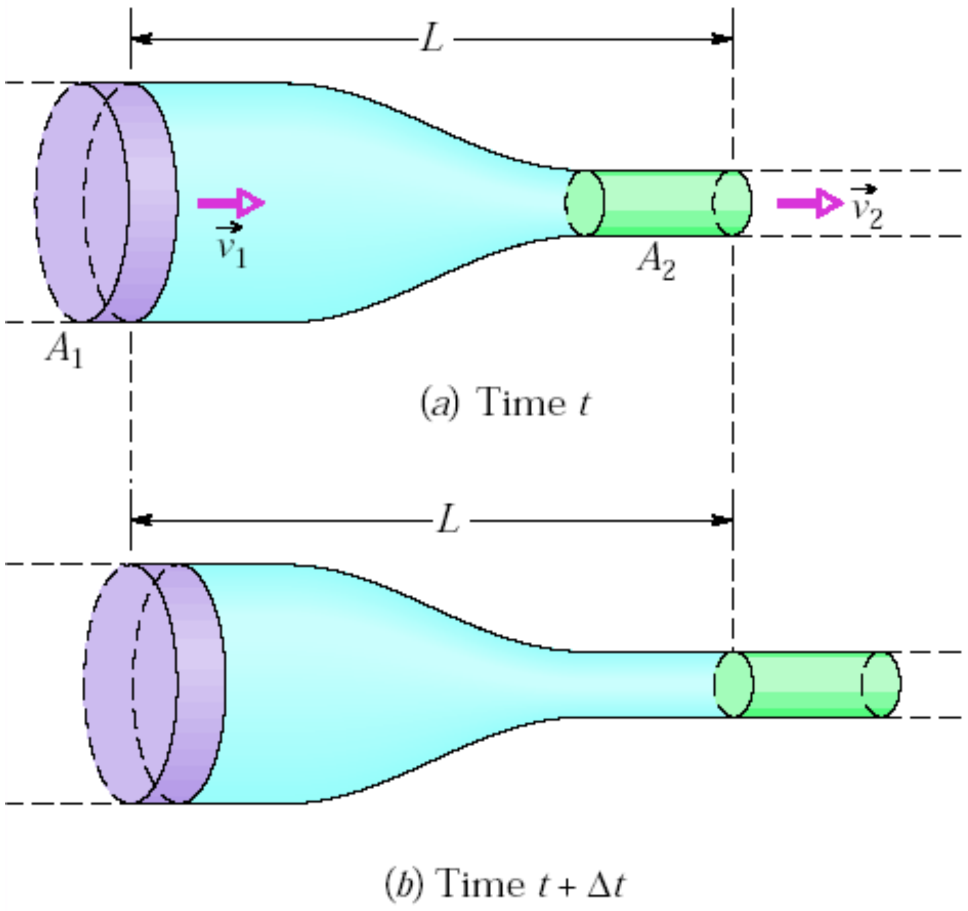
Implications of conservation of matter

- "What goes in must come out."
- Assume motion of a fluid of uniform density in a non-uniform tube.

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

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

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



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.