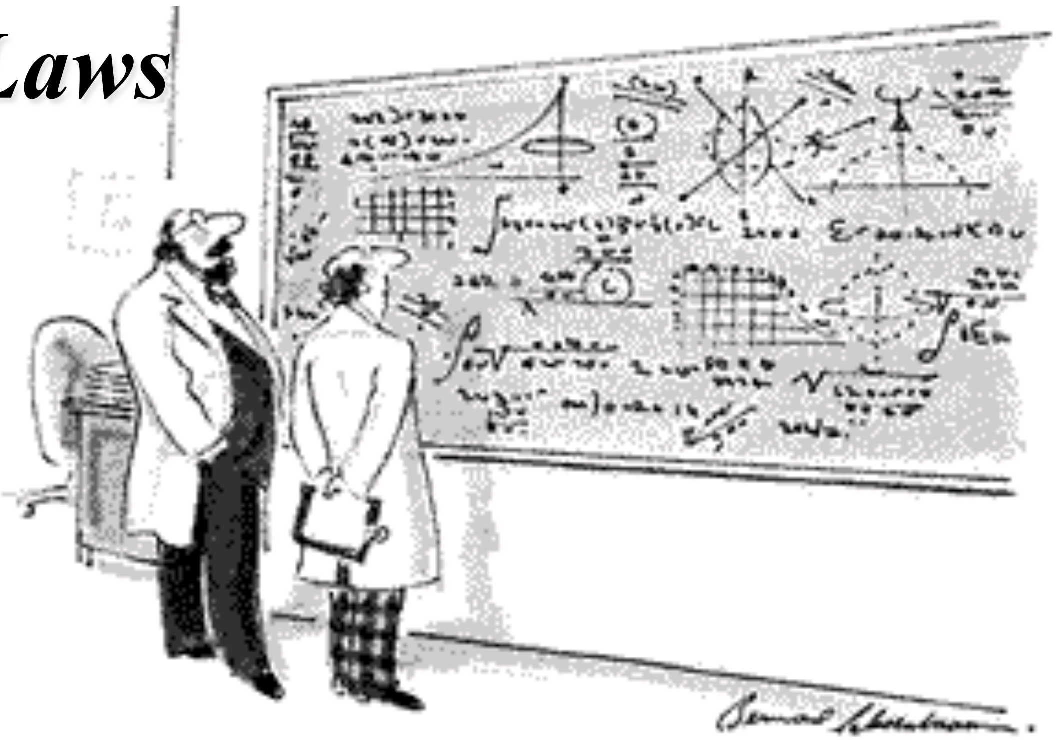
- **<u>Theme Music:</u>**
  Flanders & Swann

First & Second Laws

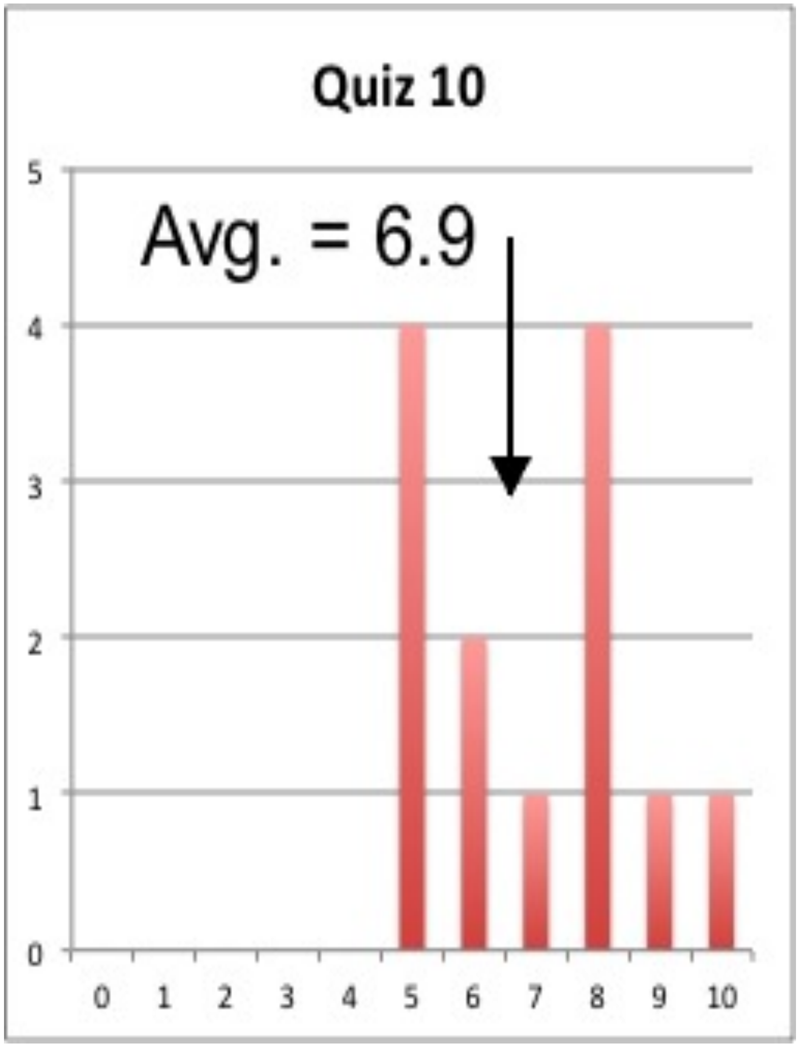
- **<u>Cartoon:</u>**
  Bernard Schoenbaum



"Oh, if only it were so simple."

Quiz 10

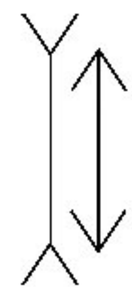
	10.1	10.2	10.3	10.4
A	**77%**	0%	**31%**	62%
B	0%	0%	**85%**	**31%**
C	**100%**	**100%**	**23%**	0%
D	0%	8%	**38%**	8%
E	38%		0%	
F	0%		0%	



Real-World Intuition 1: Reconsidered

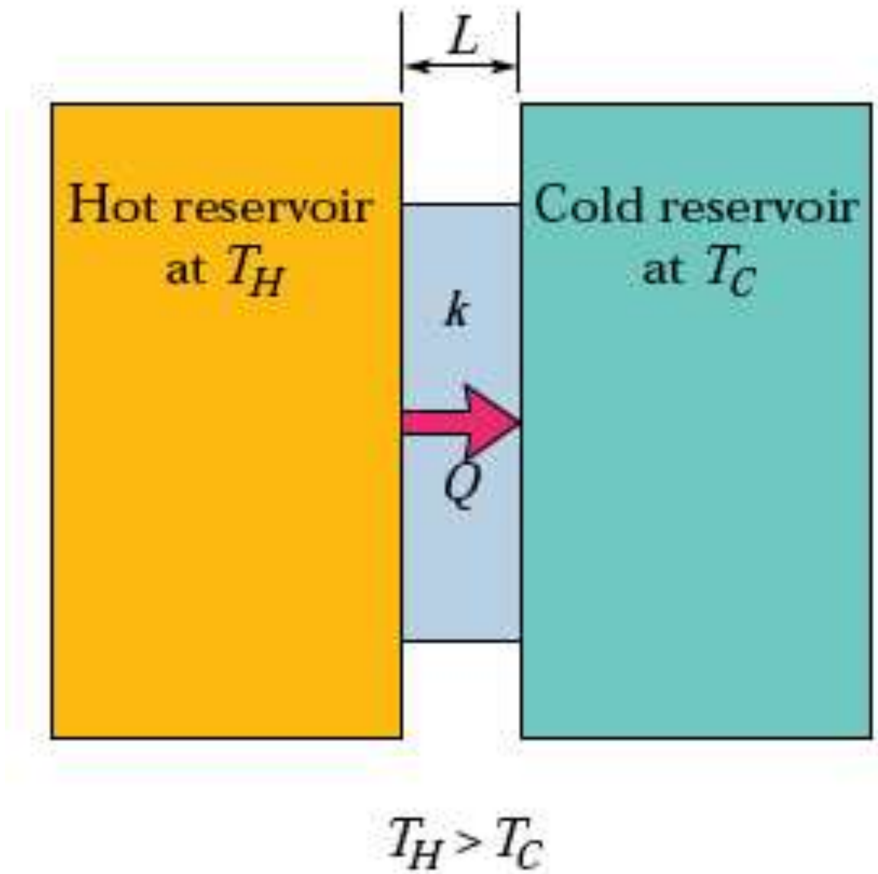
– If we have a cup of hot water and a cup of cold water and we put them aside for a while, what will happen to them?

– If you touch the cloth part of your chair and the metal part, which feels warmer?



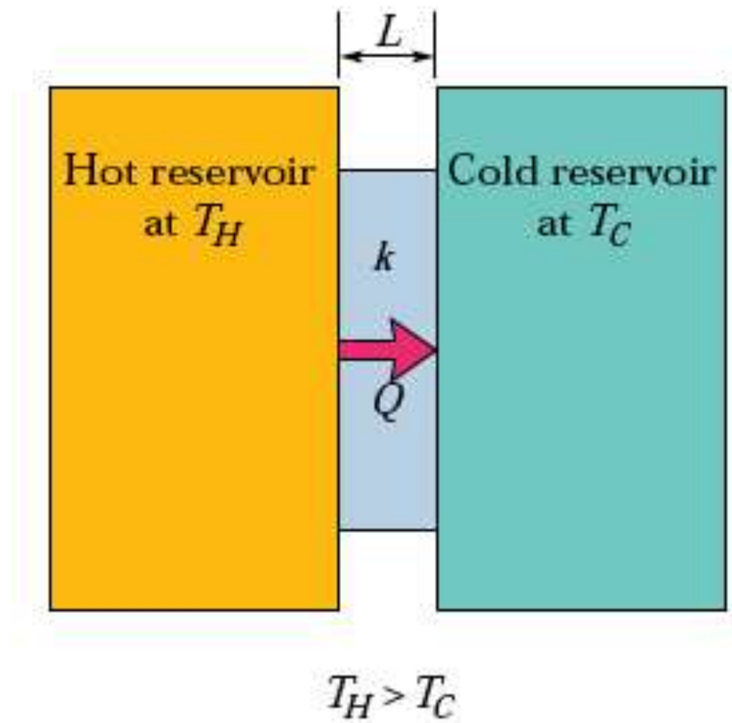
Heat Flow by Conduction

- Simplest case (again)
  - Hot block at T_H
  - Cold block at T_C
  - Connecting block that carries ("conducts") thermal energy from the hot block to the cold.



Creating an equation

- Φ = Flow
  = heat energy/sec
  $[\Phi]$ = Joules/s = Watts
- What drives the flow?
- How does the rate of flow depend on the property of the connecting block?



The Heat Flow Equation

$$\Delta T = Z\Phi$$

- We expect the flow to
  - Be less for a longer block (L)
  - Be more for a wider block (A)

$$Z = \rho \frac{L}{A}$$

- ρ = thermal resistivity – a property of the kind of substance the block is made of

A more standard form

- We have written the heat flow equation to have it match the HP equation. It is more standardly written this way:

Heat flow per unit area

$$\phi = \frac{\Phi}{A} \qquad k = \frac{1}{\rho}$$

Thermal conductance

- The equation then becomes

$$\Delta T = Z\Phi = \frac{\rho L}{A}\Phi = \left(\frac{L}{k}\right)\left(\frac{\Phi}{A}\right)$$

$$\Delta T = R\phi$$

Thermal resistance (R-value)

Some thermal conductances

Material	*k* (W/m-C)	Material	*k* (W/m-C)
Steel	12-45	**Wood**	0.4
Aluminum	200	**Insulation**	0.04
Copper	380	**Air**	0.025