February 10, 2017 Physics 132 Prof. E. F. Redish

- **Theme Music:** Desi Arnaz

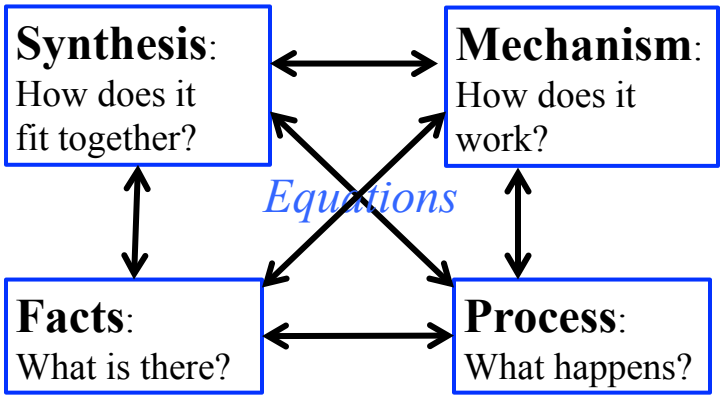
  Perhaps, perhaps, perhaps

- **Cartoon:** Pat Brady

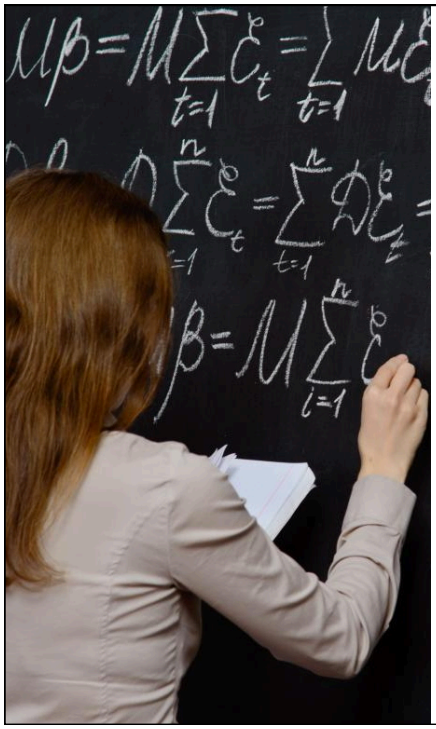
  Rose is Rose

2/10/17 Physics 132 **1**

The structure of science knowledge



2/10/17 Physics 132 **4**



The Equation of the Day

Entropy (Thermodynamics definition)

$$\Delta S = \frac{Q}{T}$$

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Physics 132

Foothold ideas: Entropy

- ***Entropy*** – an extensive* measure of how well energy is spread in an object.
- Change in entropy upon heat flow (exchange of thermal energy)

$$\Delta S = \frac{Q}{T}$$

** Extensive = proportional to the amount of stuff you have (like mass)*
Intensive = independent of the amount of stuff you have (like density)

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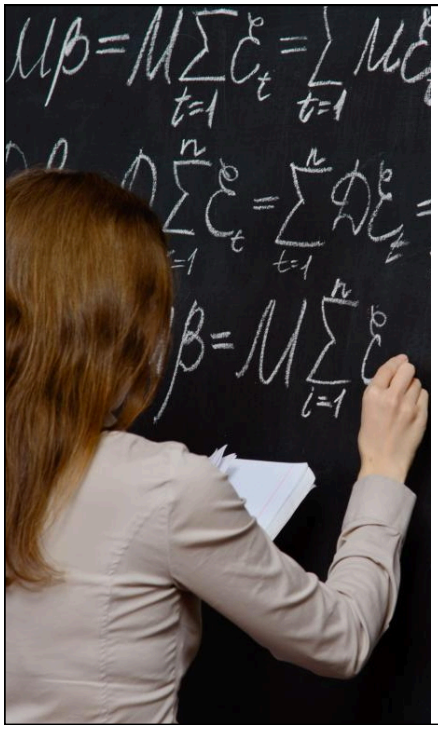

The Equation of the Day

Entropy (Information definition)

$$S = k_B \ln W$$

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Physics 132

Foothold ideas: Entropy

- ***Entropy*** – an extensive* measure of how well energy is spread in an object.
- Entropy measures
  - The number of microstates in a given macrostate
  - The amount that the energy of a system is spread among the various degrees of freedom

$$S = k_B \ln(W)$$

** Extensive = proportional to the amount of stuff you have (like mass)*
Intensive = independent of the amount of stuff you have (like density)

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How is entropy extensive?

- W_A = number of microstates for system A
- W_B = number of microstates for system B
- $W_{total} = W_A W_B$
- $S_A = k_B \ln W_A$
- $S_B = k_B \ln W_B$
- $S_{AB} = k_B \ln (W_A W_B) = k_B \ln W_A + k_B \ln W_B$
- $S_{AB} = S_A + S_B$

Foothold ideas: Exponents and logarithms

- Power law: $f(x) = x^2 \quad g(x) = Ax^7$
  a variable raised to a fixed power.
- Exponential: $f(x) = e^x \quad g(N) = 2^N \quad h(z) = 10^z$
  a fixed constant raised to a variable power.
- Logarithm: the inverse of the exponential.

$$x = e^{\ln(x)} \qquad x = \ln\left(e^x\right)$$

$$y = 10^{\log(y)} \qquad y = \log\left(10^y\right)$$

Logs convert multiplying to adding!

$$\log(2) = 0.3010$$
$$\log(e) = 0.4343$$
$$2^N = \left(10^{0.3010}\right)^N \approx 10^{0.3N}$$
$$e^x = \left(10^{0.4343}\right)^x \approx 10^{0.4x}$$
$$2^N = B$$
$$N \log 2 = \log B \Rightarrow N = \frac{\log B}{\log 2}$$