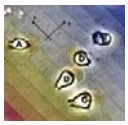
Physics 131- Fundamentals of Physics for Biologists I



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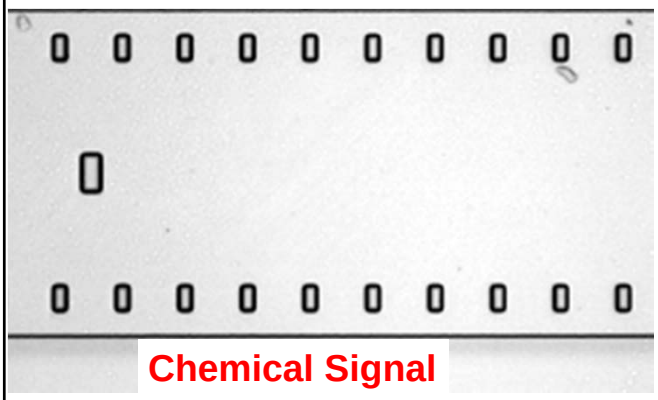


Movie of the Day
CHEMOTAXIS

Review of 8/29/2012

- New class –
  - new physics at the convergence with biology and chemistry
  - taught in a "flipped class" with prereading and hands on in class activity
- Be aware of how you learn!
  - Develop a framework of "intuition" for scientific reasoning
  - Question whether your intuitive answer makes sense
  - Learn to explain your reasoning to your peers and to challenge their reasoning

Topics

- Math in natural sciences
- Units and dimensions
- Estimation
- Scaling

Math in math vs Math in the natural sciences

I keep comments anonymous (add your name to the comment if you would like me to know your name associated with a comment)

"Does "math in math" refer to math that is purely theoretical, without any context?"

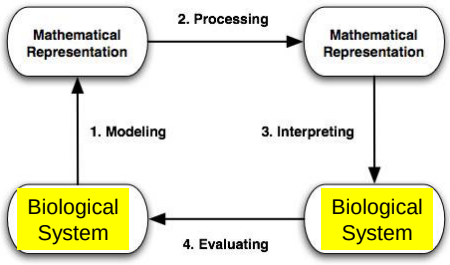
"Isn't calculus considered an evaluation process as well, with problems such as trigonometry- where the answer isn't a designated value but rather a simplified expression from the original, given solution?"

"I would like to know an example where the mathematical equation has taught scientists new insight about a physical system. "

"Why does the article try to explain math in math classes as useless knowledge to get to a meaningless number?"

Foothold ideas: Modeling the world with math

- We use math to model relationships and properties in physical, chemical or biological systems. (1)
- Mathematical processing allows us to make predictions (2) from the model that we can interpret (3) for the physical system.
- Very non-natural physical systems such as lasers, transistors have been designed via such *"model based extrapolation"*.
- In biology, steps 1 and 3 are still very hard



Foothold Idea Dimensional analysis

- Modeling physical systems requires numbers, i.e. measurements
- Measurements have dimensions:

This is what the brackets mean!

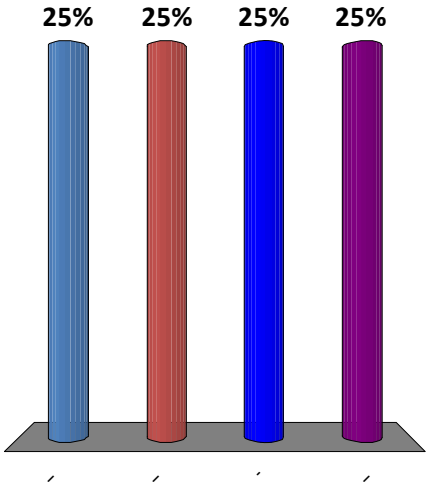
[x] = L means "the dimension of x is a Length"
[t] = T means "the dimension of t is a Time"
[m] = M means "the dimension of m is a Mass"
[v] = L/T means "the dimension of velocity is Length/Time

Models allow us to think about how the numbers fit together

<u>A first check on any model - Dimensional analysis:</u> Both sides of an equation have to have the same dimension

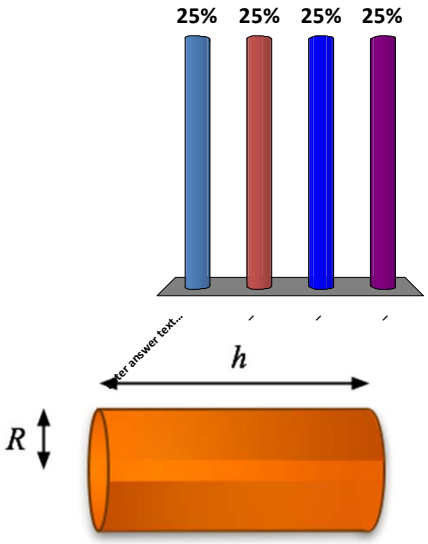
Which equation represents the volume of a sphere of radius R

1. $2\pi R$
2. $4\pi R^2$
3. $\frac{4}{3}\pi R^3$
4. πR^2



Which equation could represent the surface area of a cylinder?

1. $2\pi R + 2\pi Rh$
2. $2\pi R^2 + 2\pi Rh$
3. $2\pi R^2 + 2\pi h$
4. $\pi R^2 h$



- *It says different **items** can't be added or equated but can't you do that if you convert numbers into the same units or is it in some cases you just can't?*

Units

- Units specify which particular measurement we have chosen.
  - The same Dimension can have different units
  - Units should be manipulated like algebraic quantities.
  - Units can be changed by multiplying by appropriate forms of "1" e.g. 1 = (1 inch)/(2.54 cm)

Units are important:

A 125 Million $ Mistake

http://en.wikipedia.org/wiki/Mars_Climate_Orbiter

Syringe Sizes:

An example from a math exam

- Writing the equation in this problem on a physics exam would receive 0 credit and the comment: "This is a meaningless equation!"

The population density of trout in a stream is

$$r(x) = 20\frac{1+x}{x^2+1}$$

where *r* is measured in trout per mile and x is measured in miles. *x* runs from 0 to 10.

(a) Write an expression for the total number of trout in the stream. Do not compute it.

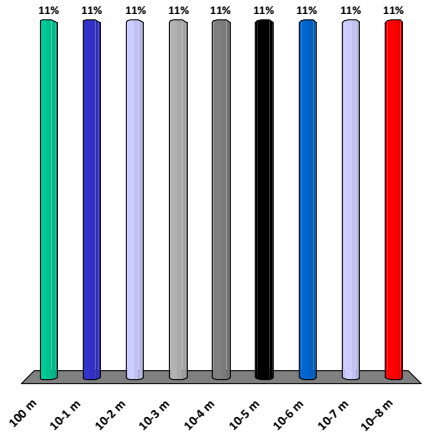
How would you fix this?

Foothold Ideas:
Estimation – Quantifying experience

- Use 1-digit arithmetic
- **Do** figure out your estimations by starting with something you can plausibly know and scale up or down
- **Do** check your answer to see if it's reasonable
- **You will learn useful numbers for biology**

Estimate the thickness of a page in a textbook.

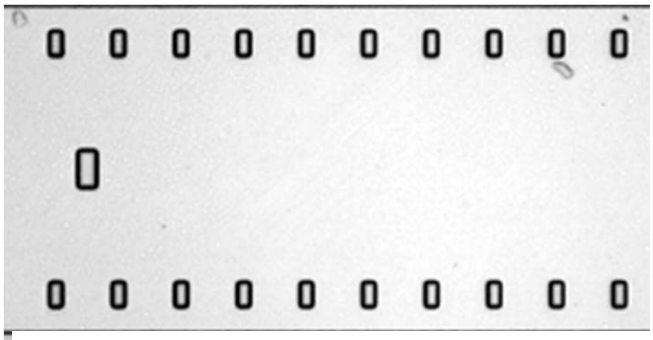
1. 10^{0} m
2. 10^{-1} m
3. 10^{-2} m
4. 10^{-3} m
5. 10^{-4} m
6. 10^{-5} m
7. 10^{-6} m
8. 10^{-7} m
9. 10^{-8} m



Estimation Problem

At typical signal strength, how many signaling molecules sweep past a moving amoeboid cell in one minute?

First number to remember: Typical concentration of signaling molecules: 10 nM



Chemical Signal comes from bottom