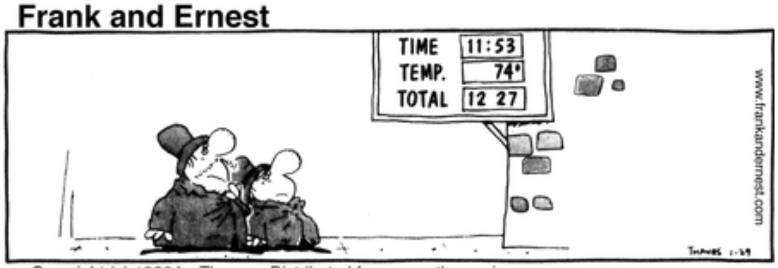
September 2, 2016 Physics 131 Prof. E. F. Redish

- **Theme Music:** **Charlie Parker**
  How deep is the ocean?
- **Cartoon:** **Bob Thaves**
  Frank and Ernest

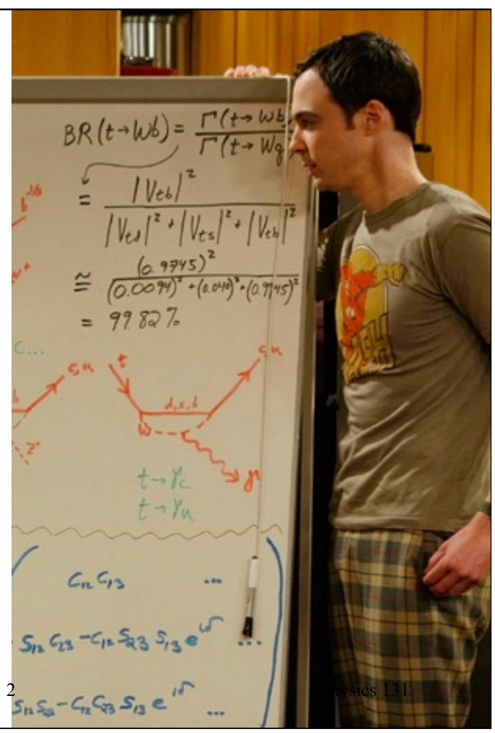
Frank and Ernest



The Equation of the Day

Dimensional analysis

$$L = L + L$$



Next week

- No class Monday (Labor Day)
- No recitation or lab
- WebAssign reading assgts. due T&Θ at 11PM.
- Clicker points count this week!
- Quiz 1 at start of class on Wednesday (Quizzes are typically based on previous week's recitation, HW, and clicker questions)
- HW 1 due on Friday
  - Paper HW due AT START of class on Friday
  - WebAssign HW due at 5PM Friday

9/2/16 Physics 131 5

Dimensions and units

- The simplest mathematical model we use in science is: we assign numbers to physical quantities by measurement.
- Each kind involves an arbitrary choice of scale.
  - Different types ↔ **dimensions**
    - » Distance, time, mass, …
  - **Equations that represent physical relationships must maintain their equality even when we change our arbitrary choice.**
- The quantity we create by adding a unit is NOT just a number but a blend of a mathematical and physical idea.

9/2/16 6 Physics 131

A dollar and a penny

- A student makes the following argument: "I can prove a dollar equals a penny. Since a dime (10 cents) is one-tenth of a dollar, I can write:

  10¢ = 0.1 $

- Square both sides of the equation. Since squares of equals are equal,

  100 ¢ = 0.01 $.

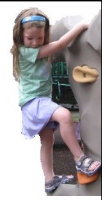
- Since 100 ¢ = 1 $ and 0.01 $ = 1 ¢ it follows that 1$ = 1 ¢."
- What's wrong with the argument?

Stuck?
Try it with
10 cm = 0.1 m

Foothold ideas

- We may choose to use an idea for a while – as a "foothold," to see how it works, and perhaps reject it later in favor of a replacement or refinement.
- These ideas become the basic principles we will use to reason – the "stakes in the ground" of our safety net.

Foothold ideas: Dimensional and unit analysis



- We label the kinds of measurement that go into assigning a number to a quantity like this:
  - $[x] = L$ means "x is a length"
  - $[t] = T$ means "t is a time"
  - $[m] = M$ means "m is a mass"
  - $[v] = L/T$ means "you get v by dividing a length by a time

L = L + L?

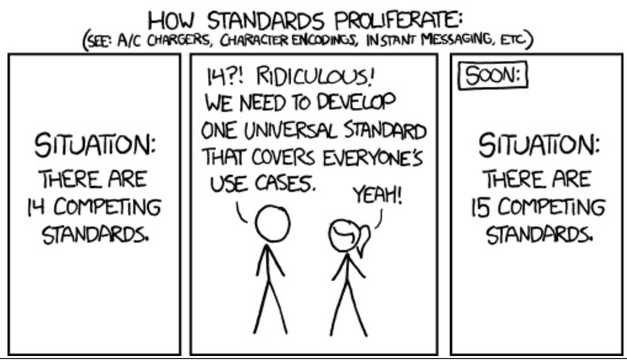
- Units specify which particular arbitrary measurement we have chosen.
  - Units should be manipulated like algebraic quantities.
  - Units can be changed by multiplying by appropriate forms of "1" e.g. 1 = (1 inch)/(2.54 cm)

Foothold ideas: Dimensional analysis

- In physics we have different kinds of quantities depending on how measurements were combined to get them. These quantities may change in different ways when you change your measuring units.
- Only quantities of the same type may be equated (or added) otherwise an equality for one person would not hold for another. Equating quantities of different dimensions yields nonsense.
- Dimensional analysis tells us *how* something changes when we either
  - Change our arbitrary scale (passive change)
  - Change the scale of the object itself (active change)

Reading question

I was reading the page under the "change" link and I was surprised that even in NASA there was issues with engineers not using the same notations. How is it possible that such an intelligent group of people haven't standardized this yet?



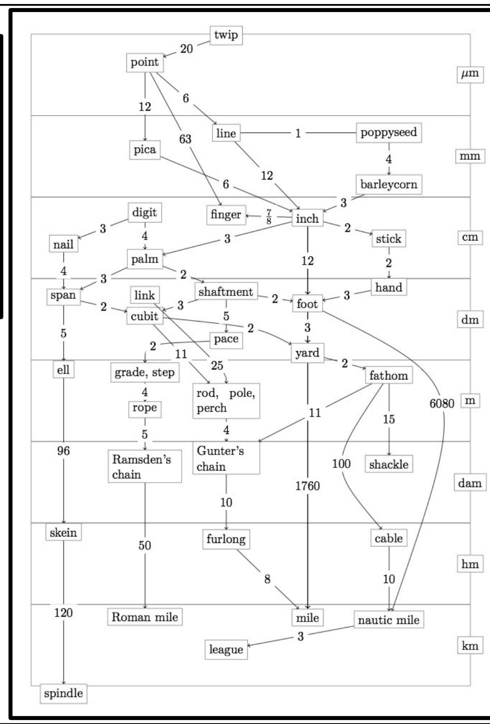
9/2/16 16

Why do we still use inches, feet, and miles instead of meters?

Tablespoons, cups, pints, quarts, and gallons instead of liters and ml?

Why do doctors still measure blood pressure in mm of Hg?

1 atm = 14.7 psi
1 atm = 760 mm of Hg
1 atm = 100 kPascal



9/2/16