How and Why do Engineers Use Math?

- Addition, subtraction, multiplication, and division
- Fractions and percents
- Rounding
- Geometry
- Graphs and experimental data
- Importance of units
- Equations

Green Bank Radio Telescope

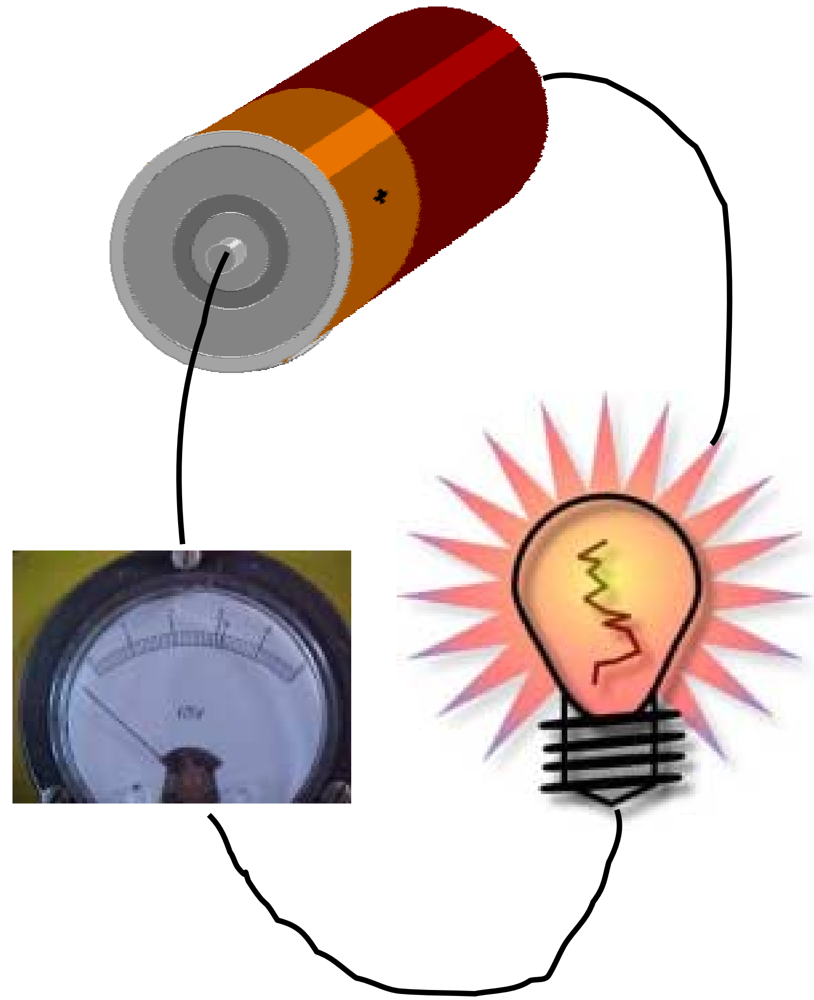
Images courtesy of NRAO/AUI

Arecibo Radio Telescope

Division and Multiplication

- Ohm’s Law:

$$Current = \frac{Voltage}{Resistance}$$



Very Large Array Radio Telescope

Image courtesy of NRAO/AUI

Single Antenna from Very Large Array

Image courtesy of NRAO/AUI

Radio Image of Saturn

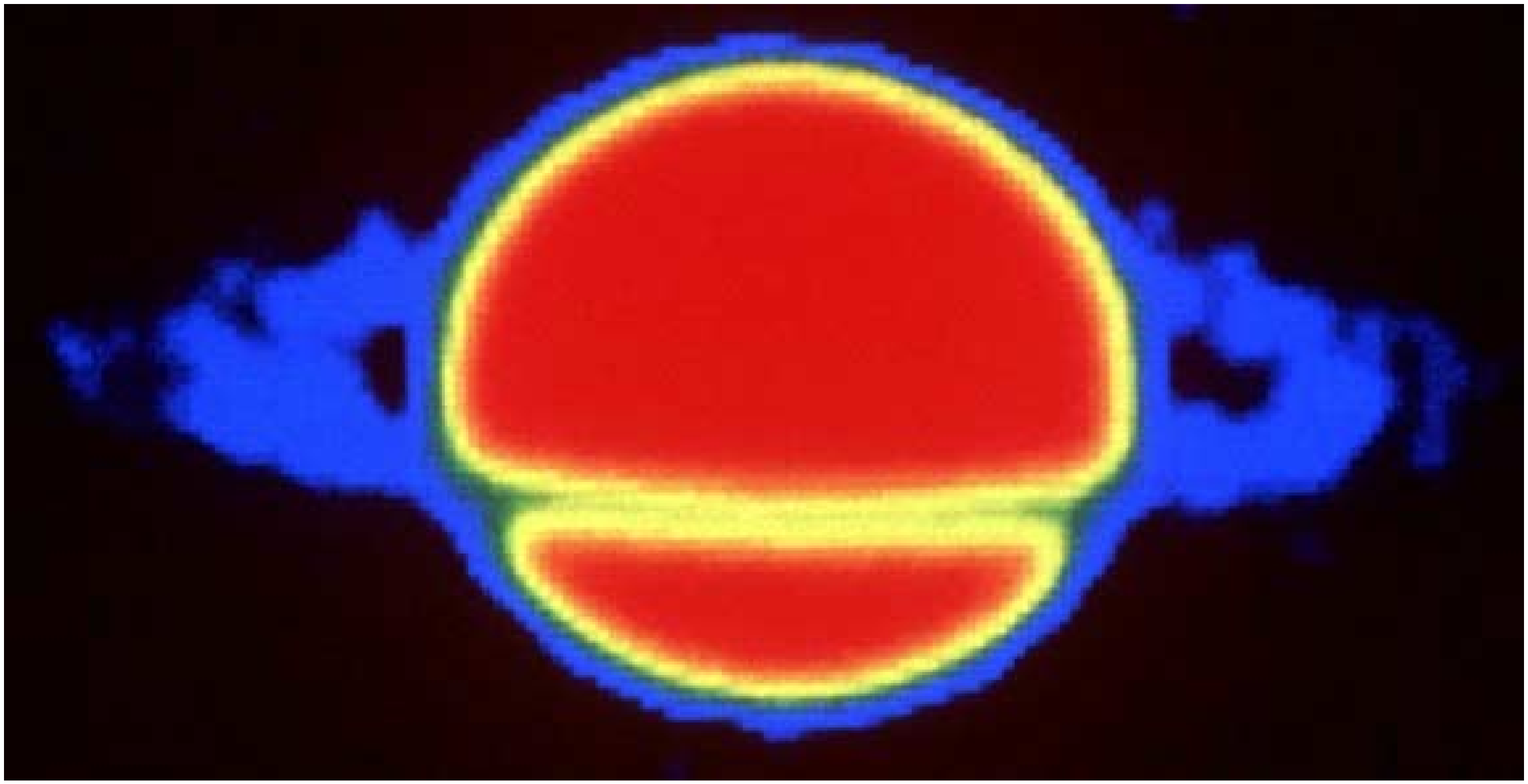


Image courtesy of NRAO/AUI

Radio Image of Black Hole

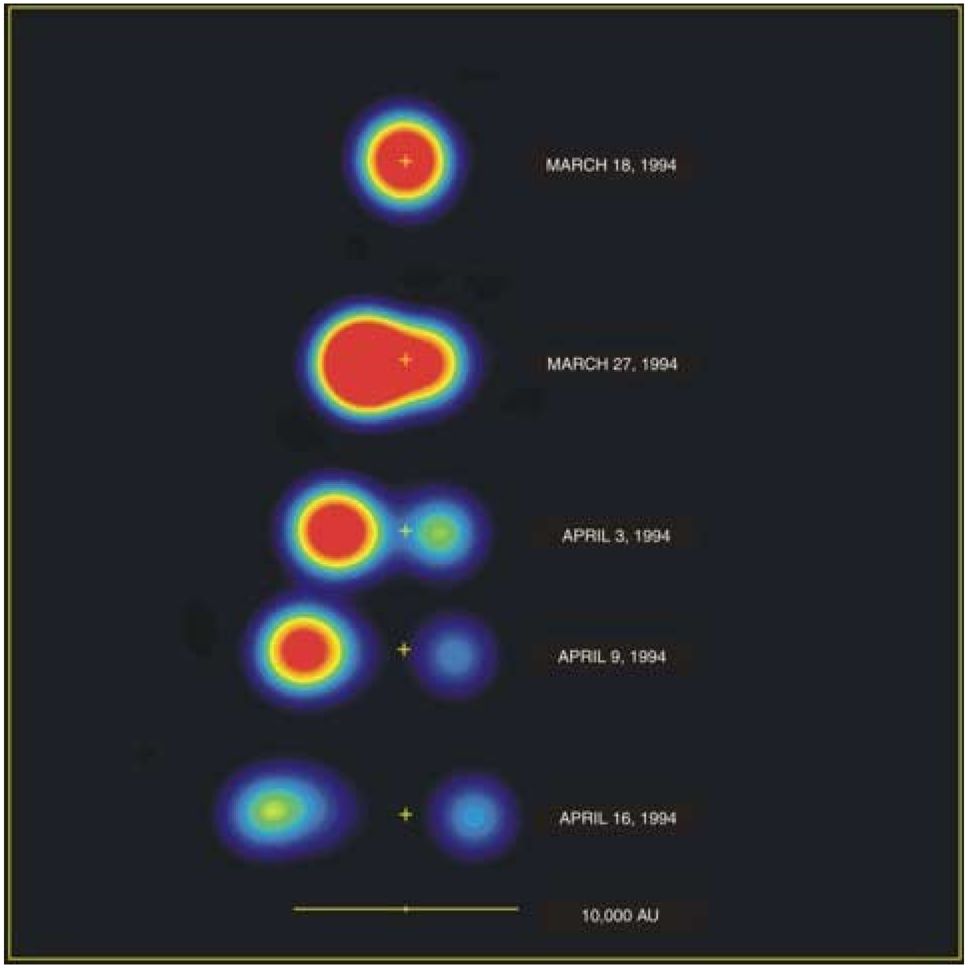
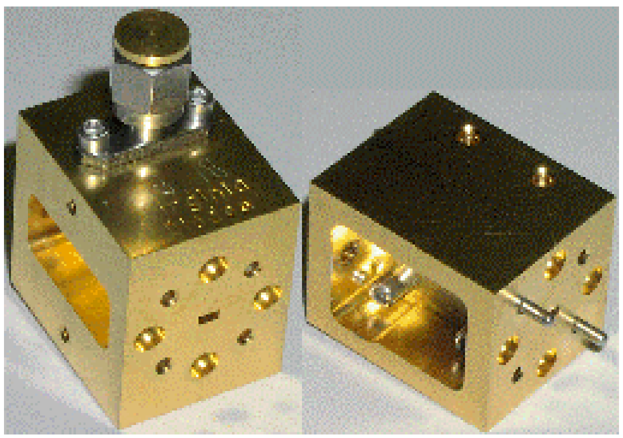
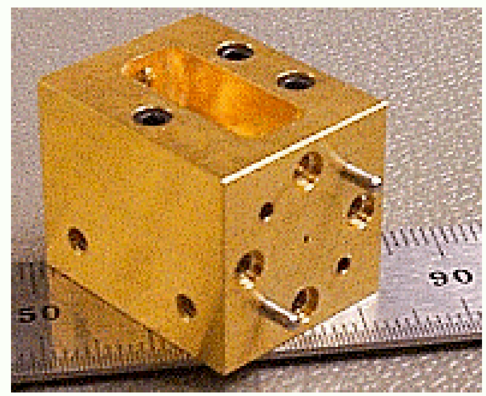


Image courtesy of NRAO/AUI

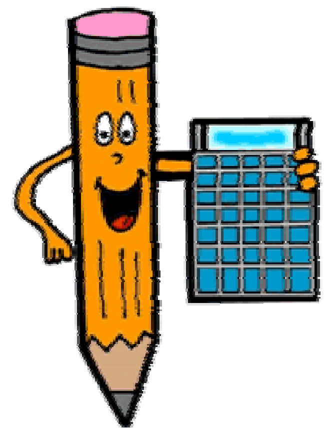
Fractions and Percents

- Engineers “scale” things to a bigger or smaller size to simplify testing them



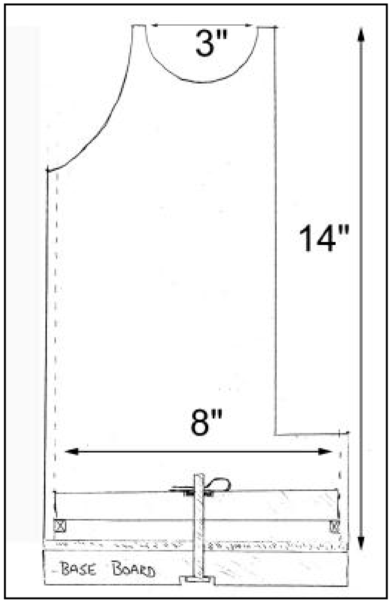


Rounding



- Calculations using calculators:
  - 17 feet / 3 = 5.66666 feet

- Measurements using voltmeter:
  - 4.335 volts

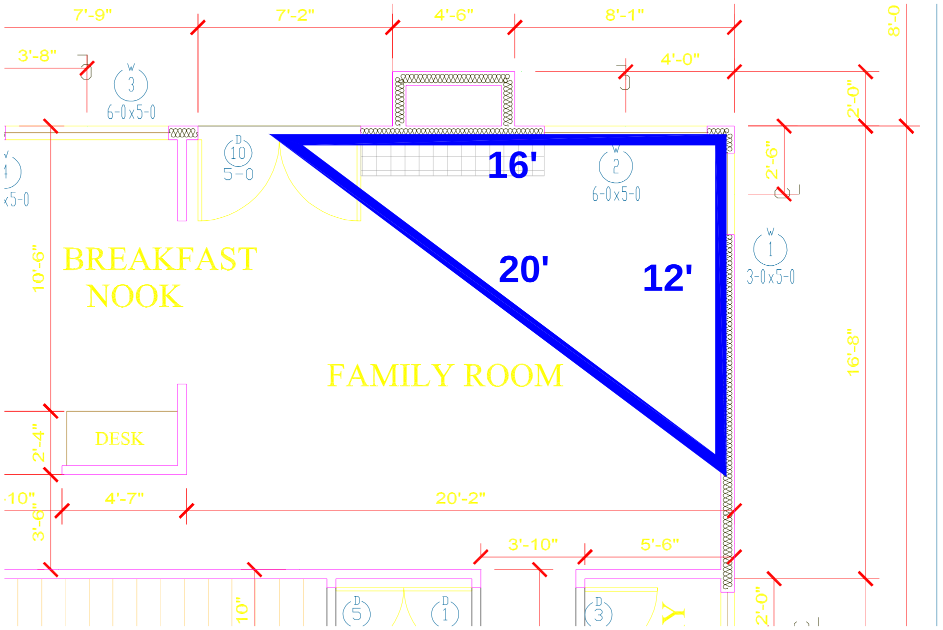


- Dimensioned Drawings

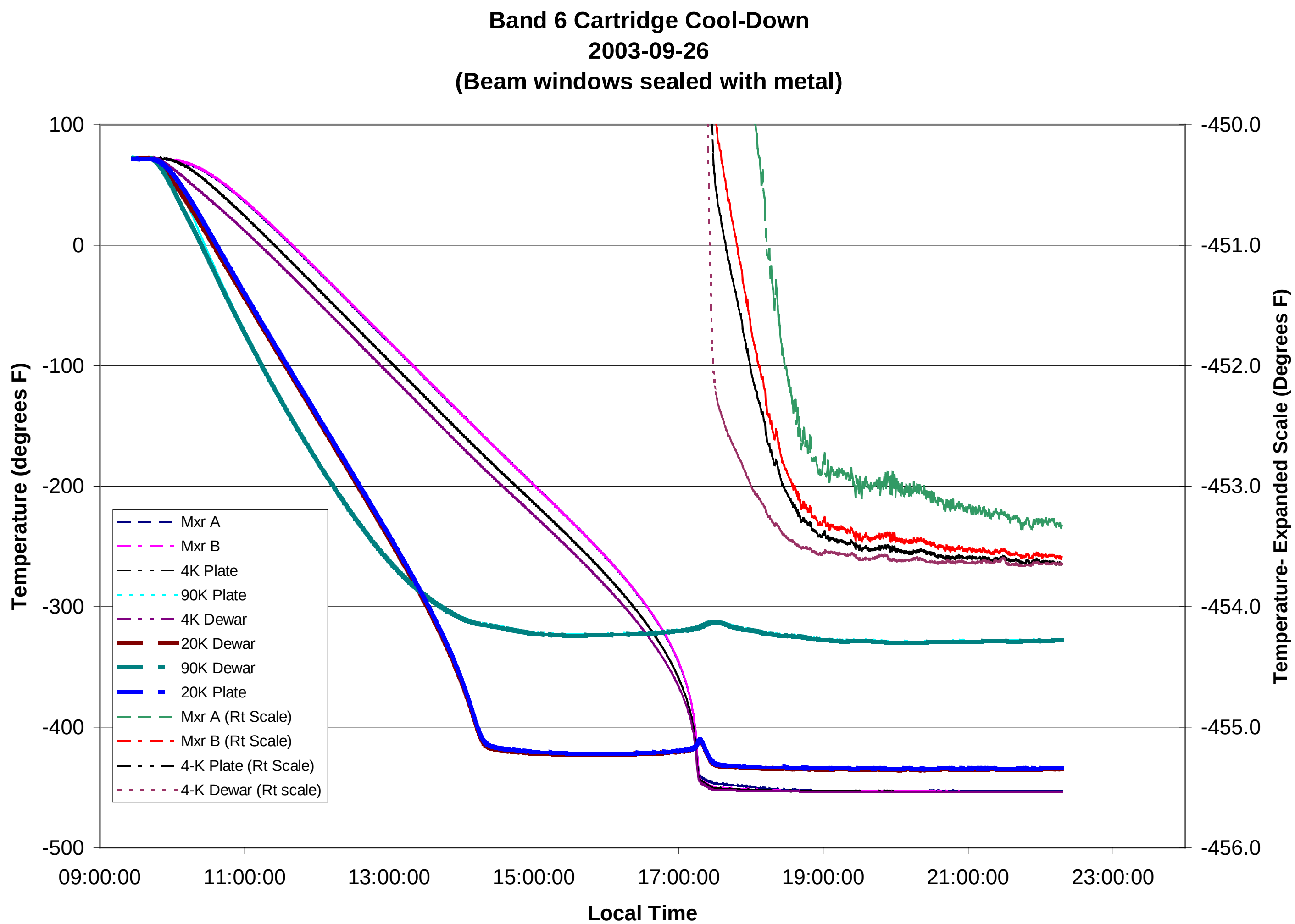
- Linear measurement: 23.400 cm is usually too precise!

Geometry

- Make walls square with “3-4-5” right triangle



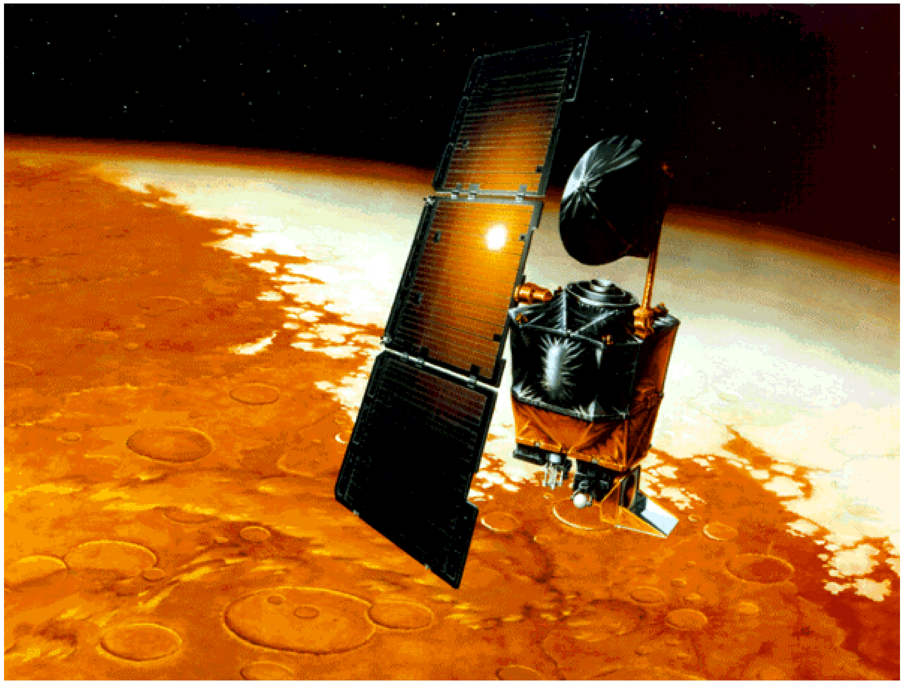
Graphs and Experimental Data



Importance of using Units: Mars Climate Orbiter

Crashed into Mars because some engineers used meters, others used feet, and nobody wrote down the units they were using!

Cost: $ 328 million!



Using Equations

Waveguide:

Maxwell's Equations:

$$\nabla \bullet \mathbf{B} = \mathbf{0}$$

$$\nabla \bullet \mathbf{D} = \mathbf{Q}$$

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

Using Equations (cont'd)

Vector Calculus Formulas simplify expressions:

$$
\begin{aligned}
\nabla \times \mathbf{H} \quad = \quad & \left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z} \right) \hat{x} + \\
& \left(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x} \right) \hat{y} + \\
& \left(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} \right) \hat{z}
\end{aligned}
$$