Chapter 1: Units and Dimensions

The Nature of Physics

What is physics?

- study of the fundamental laws of nature
- deals with the question, “what are the fundamental laws that govern natural processes?”
  - Law of Conservation of Energy: total energy of the Universe is conserved (fixed).
    - As applied to the mechanical energy of some system, this law states that the total mechanical energy is conserved if the work done by nonconservative forces is zero.
  - Law of Conservation of Linear Momentum
  - Law of Conservation of Angular Momentum

Standards and Units

standard: an agreed-upon definition of a unit of some physical quantity.

physical quantity: a property of an object or of the object's motion.

Three "Fundamental" Physical Quantities

1. length
2. mass
3. time

These three form a "fundamental set" in the sense that they can be used to derive the dimensions of (some) other physical quantities.

By the dimensions of a physical quantity, we mean, "what kind of physical quantity is it (length, mass, time, some combination of these three, etc.)."

Systems of Standard Units

1. **SI ("*mks* system")**
   - length $\rightarrow$ meter (m)
   - mass $\rightarrow$ kilogram (kg)
   - time $\rightarrow$ second (s)

2. **cgs system**
   - length $\rightarrow$ centimeter (cm)
   - mass $\rightarrow$ gram (g)
   - time $\rightarrow$ second (s)

3. **British system**
   - length $\rightarrow$ foot (ft)
   - mass $\rightarrow$ slug*
   - time $\rightarrow$ second (s)

*One slug is that mass which *weighs* 32 pounds.

Dimensional Analysis

Technique for checking an equation (the result of some HW prob. or test question, e.g.) to see whether it *could* be correct.

key idea: in any equation, the LHS and RHS must have the same dimensions.

Special Notation

- [ ] = "the dimensions of…"
- abbreviations for "fundamental three" dimensions:
  - length = L
  - mass = M
  - time = T

Note: Just because an equation is dimensionally correct, this does not *guarantee* that it is the correct equation.

Significant Figures

An issue in any *measurement*.

key idea: you cannot make any measurement (even in *principle*) with *arbitrary* precision.

Reasons:

- limited precision in the measuring device
- If you insist on making the measurement with greater and greater precision, eventually the quantity being measured loses its unique *meaning*.

Always end up having to *estimate*.

Don't want to *claim* to have made the measurement with more precision than you really did.

A significant figure ("significant digit"):

- tells some information about the precision with which the measurement was made
- is reliable

"Rules of Thumb"

- **multiplying/dividing:** keep as many significant figures in the result as there are in the number with the **fewest** significant figures.
- **adding/subtracting:** keep as many **decimal places** as there are in the number with the fewest **decimal places**.