Physics

Introduction
and
Chapter 1

Physics

- Fundamental Science
  - foundation of other physical sciences
- Divided into major areas
  - Mechanics
    - Waves
  - Thermodynamics
  - Electromagnetism
  - Modern Physics
    - Relativity
    - Quantum Mechanics
    - Nuclear

Table 1 Areas Within Physics

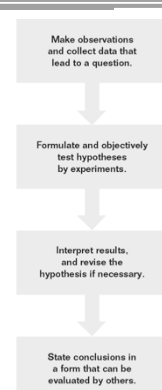
Name	Subjects	Examples
Mechanics	motion and its causes, interactions between objects	falling objects, friction, weight, spinning objects
Thermodynamics	heat and temperature	melting and freezing processes, engines, refrigerators
Vibrations and wave phenomena	specific types of repetitive motions	springs, pendulums, sound
Optics	light	mirrors, lenses, color, astronomy
Electromagnetism	electricity, magnetism, and light	electrical charge, circuitry, permanent magnets, electromagnets
Relativity	particles moving at any speed, including very high speeds	particle collisions, particle accelerators, nuclear energy
Quantum mechanics	behavior of submicroscopic particles	the atom and its parts

Why we start with Mechanics

- Has many basic principles that are used in the other major areas
- Based on studies of motion by Greeks through Galileo
- Newton's *Principia* in 1687 is the basis of our study of mechanics

Scientific Method

- Identify a Problem
- Perform Research
- Create Hypothesis
- Test Hypothesis
- Interpret Results
- Create Rule



Scientific Method Terms

- Models are often used to explain the principles of physics.
- Systems are defined to study the important components.
- All experiments must be "controlled."
  - Limit the experiment to testing one factor at a time.

Fact, Law, Theory

- **Hypothesis:** A tentative statement about the natural world leading to deductions that can be tested.
  - If the deductions are verified, the hypothesis is provisionally corroborated. If the deductions are incorrect, the original hypothesis is proved false and must be abandoned or modified.
  - Hypotheses can be used to build more complex inferences and explanations.
  - Must be Reasonable
  - Must be Testable
  - Must not be an Opinion
- **Fact:** In science, an observation that has been repeatedly confirmed and for all practical purposes is accepted as "true." Truth in science, however, is never final and what is accepted as a fact today may be modified or even discarded tomorrow.[3] A fact, is a hypothesis that has been tested over and over again with the same general results.

Fact, Law, Theory

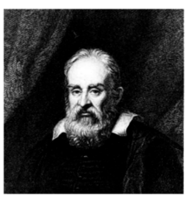
- **Law:** A descriptive generalization about how some aspect of the natural world behaves under stated circumstances.[3] A law tells what happens but not why it happens.

- **Theory:** In science, a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses.[3] A theory, tells why something happens

Examples

- **Fact:**
  - The rattle-back, when spun clockwise will stop and turn counterclockwise
- **Law:**
  - To make the rattle back a law we would have to test hundreds of them and have it become reviewed.
  - Boyle's Law PV=k
  - Newton's 3 Laws
- **Theory:**
  - To make the rattie back a theory we would have to test hundreds of them and have it become reviewed by other scientist. It would also have to explain why.
  - Electromagnetic Theories
  - Theory or Relativity

Scientific Method Founders

a  b 

Galileo Galilei (a.) and the English philosopher Francis Bacon (b.).

Mathematical Toolkit

Measurements

- Basis of testing theories in science
- Need to have consistent systems of units for the measurements
- 7 Basic Measurements all others
- Uncertainties are inherent
- Need rules for dealing with the uncertainties

Basic Quantities and Their Dimension

- Length [L]
- Mass [M]
- Time [T]

Systems of Measurement

- Standardized systems
  - agreed upon by some authority, usually a governmental body
- SI -- Systéme International
  - agreed to in 1960 by an international committee
  - main system used in this text
  - also called mks for the first letters in the units of the fundamental quantities

Metric Prefixes

- Prefixes correspond to powers of 10
- Each prefix has a specific name
- Each prefix has a specific abbreviation
- See table 1.4

SI PREFIXES

Abbreviation	Prefix	Power
G	Giga	10^9
M	Mega	10^6
k	kilo	1 000 or 10^3
h	hecta	100or 10^2
da	deka	10 or 10^1
THE BASE	-----	0
d	deci	0.1 or 10^{-1}
c	centi	0.01or 10^{-2}
m	milli	0.001 or 10^{-3}
µ	micro	10^{-6}
n	nano	10^{-9}

Length

- Units
  - Meter
- Defined in terms of a meter -- the distance traveled by light in a vacuum during a given time

Mass

- Units
  - SI – kilogram
- Defined in terms of kilogram, based on a specific cylinder kept at the International Bureau of Standards

Time

- Units
  - seconds, s in all three systems
- Defined in terms of the oscillation of radiation from a cesium atom

The other 4 basic SI Dimensions and their Units

- **Electric Current - Ampere [A]**
  - The unit of measurement of **electrical current** flow, named after André Ampère, a 19th century French physicist. One ampere is the value of current that will be maintained in a circuit with an electromotive force of one volt and a resistance of one ohm. One ampere = 6.25 x 10^{18} electrons/ second
- **Temperature - Kelvin [K]**
  - The Kelvin is the basic unit of **temperature**. It is 1/273.16*th* of the thermodynamic temperature of the triple point of water. *It is named after the Scottish mathematician and physicist William Thomson 1st Lord Kelvin (1824-1907).*

The other 4 basic SI Dimensions and their Units

- **Substance - mole [mol]**
  - The mole is the basic unit of **substance**. It is the amount of substance that contains as many elementary units as there are atoms in 0.012 kg of carbon-12.
- **Luminous Intensity - candela [cd]**
  - The candela is the basic unit of **luminous intensity**. It is the intensity of a source of light of a specified frequency, which gives a specified amount of power in a given direction.

All Other SI Units

- All other SI units are derived from the 7 basic dimensions just mentioned.
- Example
  - Distance/ Time = [meter/second]

SI Base Units

Quantity Measured	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Intensity of light	candela	cd

Dimensional Analysis

- Technique to check the correctness of an equation
- Dimensions (length, mass, time, combinations) can be treated as algebraic quantities
  - add, subtract, multiply, divide
- Both sides of equation must have the same dimensions

Dimensional Analysis, cont.

- Cannot give numerical factors: this is its limitation
- Example
  - foot * yd / foot = yd
  - Slug * gram / slug = gram

Conversions

- When units are not consistent, you may need to convert to appropriate ones
- Units can be treated like algebraic quantities that can cancel each other out
- Look at the conversion list provided

Conversion Factors

- **1 meter = 3.2808399 feet**
- **1 slug = 14.5939029 kilogram**
- **1 mile = 1.609344 kilometer**
- **1 pound force = 4.44822162 Newton**
- When ever you need a conversion factor use the following format on google ("what you have" to "what you want")

Factor Label Method

- We take the dimensions we have, and determine which dimension we are looking for. By multiplying what we have by a series of conversion factors we get what we are looking for
- 100 yards to miles
- 100 yards * 3 feet / 1 yard * 1 mile / 5280 feet=

Scientific Notation

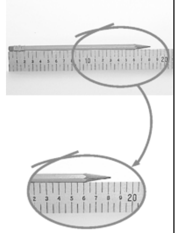
- Placing numbers in scientific (exponential) notation has several advantages.
  - For very large numbers and extremely small ones, these numbers can be placed in scientific notation in order to express them in a more concise form.
  - In addition, numbers placed in this notation can be used in a computation with far greater ease. This last advantage was more practical before the advent of calculators and their abundance.

Scientific Notation

- Placing numbers in scientific notation from standard form with the following rules:
  - Move the decimal so that there is only 1 non-zero number to the left of the decimal.
  - If you move the decimal to the left add the number of moves you made to the exponent.
  - If you move the decimal to the right subtract the number of move you made from the exponent
- Placing number in standard notation from scientific notation
  - If the power is positive move the decimal to the right an equal number of spaces as the exponent.
  - If the power is negative move the decimal the left an equal number of spaces as the exponent.

Accuracy vs Precision

- Accuracy describes the nearness of a measurement to the standard or true value, i.e., a highly accurate measuring device will provide measurements very close to the standard, true or known values. Example: in target shooting a high score indicates the nearness to the bull's eye and is a measure of the shooter's accuracy.



Accuracy vs Precision

- Precision is the degree to which several measurements provide answers very close to each other. It is an indicator of the scatter in the data. The lesser the scatter, higher the precision.

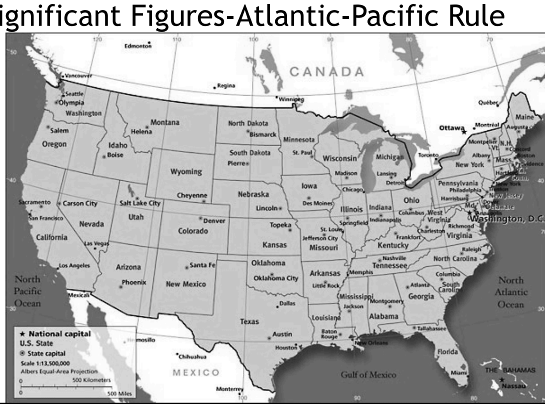
Approximations

- Even though physicists usually try for a high degree of precision, there are times when only a close approximation is needed. Physicists some times make rough estimates for making tentative decisions. The accuracy of estimates depends on reference materials available, time devoted, and experience with similar problems.

Significant Figures

- A significant figure is one that is reliably known
- All non-zero digits are significant
- Zeros are significant when
  - between other non-zero digits
    - 502 the zero is significant
    - 5130 the zero is not significant
  - after the decimal point and another significant figure
    - 15.03, the zero is significant
    - 0.0183, the zero is not significant
  - can be clarified by using scientific notation

Significant Figures-Atlantic-Pacific Rule



Operations with Significant Figures

- Accuracy -- number of significant figures
- When multiplying or dividing, round the result to the same accuracy as the least accurate measurement
- When adding or subtracting, round the result to the smallest number of decimal places of any term in the sum

Problem Solving Strategy