Chapter 1

Physics, the Fundamental Science

What is Physics?

An *experimentally* based science with a goal of understanding and explaining the *fundamental* principles that govern the physical universe.

Physics is not just about learning facts, but about doing experiments to understand how the universe operates. We will try to understand the principles that have been learned through experimentation and solve problems using those principles.
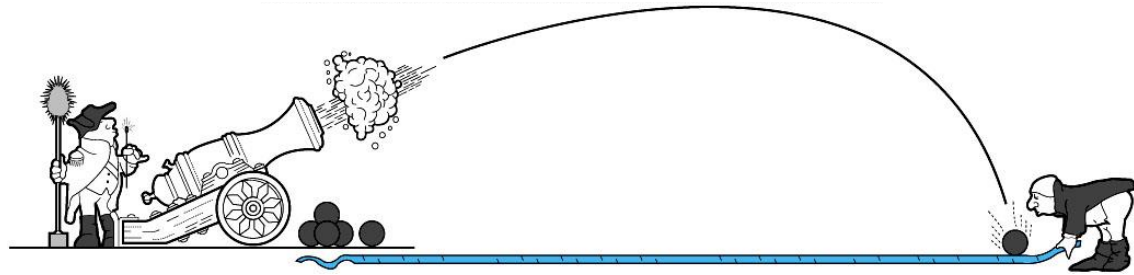
"The goal of physics is to predict the future."

-Dr. C. Fronsdal (UCLA)
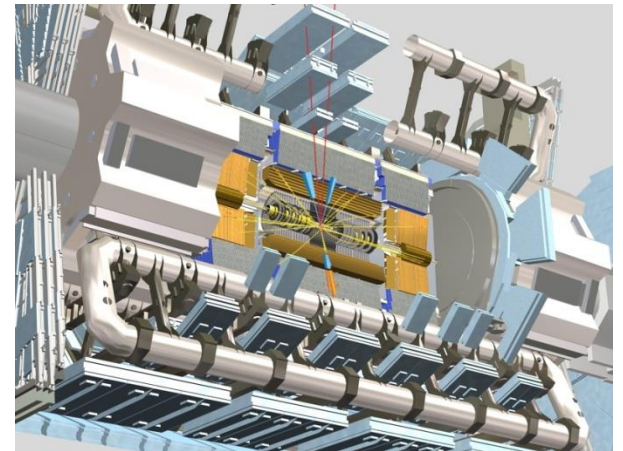
Subfields of Physics

- ## Classical Physics
  - Mechanics - forces and motion
  - Thermodynamics - temperature, heat, energy
  - Electricity and Magnetism
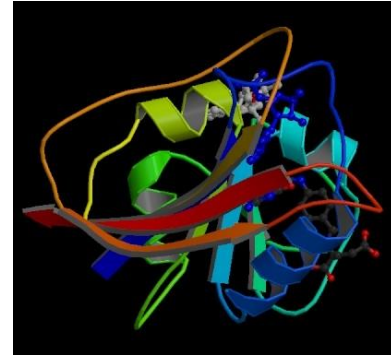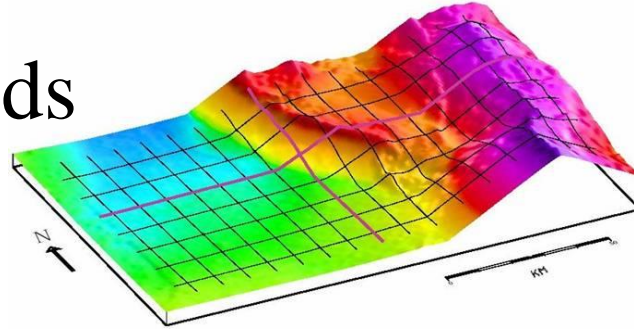 - Optics - light

- ## Modern Physics
  - Atomic physics - atoms
  - Nuclear physics - nucleus of the atom
  - Particle physics - subatomic particles: quarks, etc
  - Condensed matter physics - solids and liquids

Subfields of Physics
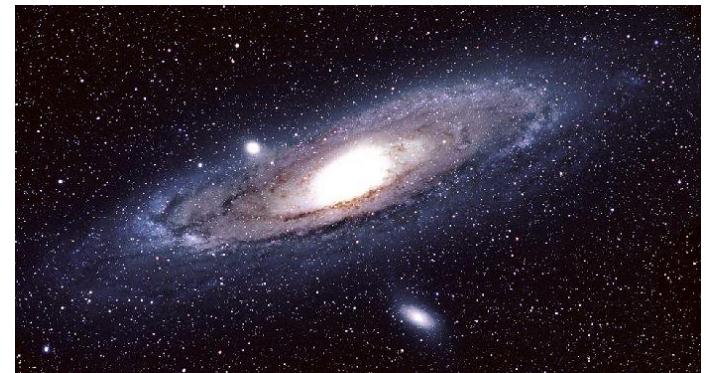
- Interdisciplinary Fields
  - Biophysics
  - Geophysics
  - Astrophysics

➢ Physicists: fundamental understanding
➢ Engineers: practical applications
  - Often overlapping roles

Scientific Laws and Theories

- In modern language both mean the same thing
- They are a generalization of a principle of nature based on observation and experiment
  - Before ~1900: Called a law
  - After ~1900: Called a theory
- They can always be refined or falsified based on experiment
- Has a realm of application
  - Some laws/theories seem to always be true
  - Some laws/theories are more confined

Scientific Notation

Uses exponents to display numbers

1) $213 = 2.13 \times 10^2$
2) $65,700 = 6.57 \times 10^4$
3) $0.00473 = 4.73 \times 10^{-3}$
4) $0.0000665 = 6.653 \times 10^{-5}$

In webassign this is written as an exponent (E)

1) $213 = 2.13E2$
2) $0.00473 = 4.73E-3$

On many calculators this is the EE or EXP key.

Interactive Question

The radius of the Earth is 6,380,000 m at the equator.
Give the radius of the earth in scientific notation.

A) 6380×10^3 m
B) 6.38×10^3 m
C) 6.38×10^5 m
D) 6.38×10^6 m
E) 6.38×10^{-6} m

Metric System

We will use both the metric system and the English system, but mostly the metric system

	Metric	English
Time	second (s)	second (s)
Length	meter (m)	foot (ft)
Mass	kilogram (kg)	slug (slug)
Force	newton (N)	pound (lb)

I will give you needed conversion factors on tests. For homework, check the front of the textbook, or the web.

Metric Prefixes

Prefix	Symbol	Size	Meaning (multiply by)
peta	P	10^{15}	1 000 000 000 000 000
tera	T	10^{12}	1 000 000 000 000
giga	G	10^{9}	1 000 000 000
mega	M	10^{6}	1 000 000
kilo	k	10^{3}	1000
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	μ	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	p	10^{-12}	0.000 000 000 001
femto	f	10^{-15}	0.000 000 000 000 001

Interactive Question
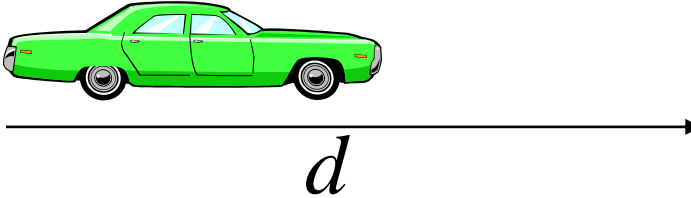
A meter is

A)   1000 times larger than a kilometer

B)   100 times longer than a kilometer

C)   1 /10 as long as a kilometer

D)   1/100 as long as a kilometer

E)   1/1000 as long as a kilometer

Physics and Mathematics

- To really understand a phenomena, we must be able to describe it both qualitatively and quantitatively.
- So we will use some mathematics and algebra in this class.

In physics, the equations have meaning:

$$s = d/t$$

We read this as average speed equals distance divided by time or as the distance traveled during a particular time interval.

Some Algebra

$s = d/t$

$st = dt/t$ ⟵ Anything divided by itself is 1

$st = d$

$d = st$

- We read this as distance equals average speed times time.
- The top and bottom equations are really the same equation, just rearranged
- You should be able to do high school level algebra and the math in Appendices A and B.

Some Notation

These all mean the same thing: s times t

- st
- $(s)(t)$
- $s \times t$

- $s \cdot t$
- $s * t$ (in webassign)

These all mean the same thing: s divided by t

- s/t
- $s \div t$

Be careful: in webassign (and on most calculators)

$$a / b * c = \frac{a \times c}{b} \qquad\qquad a / (b * c) = \frac{a}{b \times c}$$

Also on webassign: $ab \neq a*b$. You must write a*b

Working with equations

$d = st$

- The distance traveled is equal to the average speed times time.
- If you travel at 60 miles/hour for 1/2 (0.5) hours, then you find:

  $d = st$

  $\quad = (60 \text{ miles/hour})(0.5 \text{ hours}) = 30 \text{ miles}$

Interactive Question

A test of algebra: Which of the following pairs of equations *do not* represent an identical equation?

A) $x = vt$, $v = x/t$

B) $a/b = c$, $ac = b$

C) $6xy - 5xz$, $x(6y - 5z)$

D) $3qr - 4qr$, $-qr$

E) More than one of the above

Units

A number without units is meaningless:

"I'm driving with a speed of 30."

We usually use the International System of Units (Système International (SI)) units.

Length: meter (m)
Time: second (s)
Mass: kilogram (kg)

Using units properly is a skill you should be able to do. This may be a necessary part of many problems.

<u>Problem</u>: How many minutes are in a year?

<u>Problem</u>: You are traveling 65 miles/hour. How fast is that in meters/second?

Solving Problems in Class

- In class, I will solve problems using the techniques and principles that will be on homework and exams.

- These will not be the same problems on the homework or exams, but use the same principles.

- It is most important that you understand the principles and techniques so that you can use those ideas to solve other problems.

- You will not learn to solve the problems by simply watching a few representative examples from me.

- You must learn to solve the problems on your own by working through homework and examples in the book.

<u>Problem</u>: A swimming pool is filled with 16,000 cubic feet of water. How many cubic meters is this?

The answer in the above problem is 450 m^3 even though a calculator would have given 453.0695 m^3. We only use the correct number of significant figures.

Number	Number of Sig. Fig.
25	2
25.0	3
310	2 or 3?
3.10×10^2	3
0.0045	2
0.00450	3
4.50×10^{-3}	3

On homework, always use 3 significant figures

Identifying significant figures

-   Non zero digits significant.
    1349.8 has 5 significant figures

-   Final or zeros to the right of decimal significant
    3.000 has 4 significant figures

-   Zeros for spacing are not significant
    0.0004 has 1 significant figures

-   Zeros between significant numbers significant
    30.0004 has 6 significant figures