Physics 207, Lecture 2, Sept. 11

Agenda for Today

- Chapter 1, Chapter 2.1, 2.2
  - ❖ Units and length scales
  - ❖ Order of magnitude calculations
  - ❖ Significant Digits
  - ❖ Position, Displacement
  - ❖ Velocity, Speed

Assignment: Finish reading Ch. 2, begin Chapter 3 (3.1 and 3.2)

- Acceleration, Direction (vectors)
- WebAssign Problem Set 1

Length:

Distance____	Length (m)
Radius of Visible Universe	1×10^{26}
To Andromeda Galaxy	2×10^{22}
To nearest star	4×10^{16}
Earth to Sun	1.5×10^{11}
Radius of Earth	6.4×10^{6}
Sears Tower	4.5×10^{2}
Football Field	1.0×10^{2}
Tall person	2×10^{0}
Thickness of paper	1×10^{-4}
Wavelength of blue light	4×10^{-7}
Diameter of hydrogen atom	1×10^{-10}
Diameter of proton	1×10^{-15}

Order of Magnitude Calculations / Estimates

Questions: What is the earth's radius in meters?

- Need to know something from your experience:
  - ❖ Flying from NYC to SF one accumulates ~ 3,000 miles
  - ❖ NYC to SF spans about 1/8 of the Earth's circumference
  - ❖ So, the Earth's circumference L = 3,000 x 8 ~ 24,000 mi
  - ❖ Since circumference of a circle is : $L = 2\pi r$
  - ❖ Estimate of Earth radius :

$$r = \frac{L}{2\pi} \approx \frac{24{,}000 \text{ mi}}{6} \approx 4{,}000 \text{ mi}$$

4×10^3 mi = 4×10^3 mi x1.6 km/mi x10 m/km ~ 6.4×10^3 km = 6×10^6 m

Time:

Interval____	Time (s)
Age of Universe	5×10^{17}
Age of Grand Canyon	3×10^{14}
Avg age of college student	6.3×10^{8}
One year	3.2×10^{7}
One hour	3.6×10^{3}
Light travel from Earth to Moon	1.3×10^{0}
One cycle of guitar A string	2×10^{-3}
One cycle of FM radio wave	6×10^{-8}
One cycle of visible light	1×10^{-15}
Time for light to cross a proton	1×10^{-24}

Mass:

Object______	Mass (kg)
Visible universe	$\sim 10^{52}$
Milky Way galaxy	7×10^{41}
Sun	2×10^{30}
Earth	6×10^{24}
Boeing 747	4×10^{5}
Car	1×10^{3}
Student	7×10^{1}
Dust particle	1×10^{-9}
Bacterium	1×10^{-15}
Proton	2×10^{-27}
Electron	9×10^{-31}

Some Prefixes for Power of Ten

Power	Prefix	Abbreviation
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	*nano*	n
10^{-6}	micro	µ
10^{-3}	milli	m
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E

See text : 1-3

Density

- Every substance has a density, designated ρ = M/V
- Dimensions of density are, $\rho \equiv \frac{M}{L^3}$ units (kg/m^3)
- Some examples,

Substance	ρ (10^3 kg/m^3)
Gold	19.3
Lead	11.3
Aluminum	2.70
Water	1.00

See text : 1-3

Atomic Density

- In dealing with macroscopic numbers of atoms (and similar small particles) we often use a convenient quantity called Avogadro's Number, $N_A = 6.023 \times 10^{23}$ atoms per mole
- Commonly used mass units in regards to elements
  1. Molar Mass = mass in grams of one mole of the substance (averaging over natural isotope occurrences)
  2. Atomic Mass = mass in u (a.m.u.) of one atom of a substance.

  It is approximately the total number of protons and neutrons in one atom of that substance.

  1u = 1.660 538 7 x 10^{-27} kg

What is the mass of a single carbon (C_{12}) atom ?

$$M \text{ (carbon)} = \frac{12.\text{ g/mol}}{6.023\times10^{23}\text{atom/mol}} = 2 \times 10^{-23}\text{ g/atom}$$

See text : 1-4

Dimensional Analysis

- This is a very <u>important</u> tool to check your work
  - ❖ Provides a reality check (if dimensional analysis fails then no sense in putting in the numbers; this leads to the GIGO paradigm)
- Example

  When working a problem you get the answer for distance

  $d = v\,t^2$ (velocity x time^2)

  Quantity on left side = L

  Quantity on right side = L / T x T^2 = L x T
- Left units and right units don't match, so answer is nonsense

Lecture 2, *Exercise 1*
Dimensional Analysis

- **The force (F) to keep an object moving in a circle can be described in terms of:**
  - ❖ **velocity (v, dimension L/T) of the object**
  - ❖ **mass (m, dimension M)**
  - ❖ **radius of the circle (R, dimension L).**

Which of the following formulas for *F* <u>*could*</u> be correct ?

(a) $F = mvR$ **(b)** $F = m\left(\frac{v}{R}\right)^2$ **(c)** $F = \frac{mv^2}{R}$

Note: *Force* has dimensions of ML/T^2

Text : 1-5

Converting between different systems of units

- Useful Conversion factors:
  - ❖ 1 inch = 2.54 cm
  - ❖ 1 m = 3.28 ft
  - ❖ 1 mile = 5280 ft
  - ❖ 1 mile = 1.61 km
- Example: Convert miles per hour to meters per second:

$$1\frac{\text{mi}}{\text{hr}} = \frac{1\,\text{mi}}{\text{hr}}\times\frac{5280\,\text{ft}}{\text{mi}}\times\frac{1\,\text{m}}{3.28\,\text{ft}}\times\frac{1\,\text{hr}}{3600\,\text{s}} = 0.447\frac{\text{m}}{\text{s}} \approx \frac{1}{2}\frac{\text{m}}{\text{s}}$$

Lecture 2, *Exercise 2*
Converting between different systems of units

- When on travel in Europe you rent a small car which consumes 6 liters of gasoline per 100 km. What is the MPG of the car ?

  (There are 3.8 liters per gallon.)

$$\frac{100}{6}\frac{\text{km}}{l} = \frac{100\,\text{km}}{6\,l}\times\frac{\text{mi}}{1.6\,\text{km}}\times\frac{3.8\,l}{\text{gal}} = 39.6\frac{\text{mi}}{\text{gal}} = 40\frac{\text{mi}}{\text{gal}}$$

See text : 1-7

Significant Figures

- The number of digits that have merit in a measurement or calculation.
- When writing a number, all non-zero digits are significant.
- Zeros may or may not be significant.
  - those used to position the decimal point are **not** significant (unless followed by a decimal point)
  - those used to position powers of ten ordinals may or may not be significant.
- In scientific notation all digits are significant
- Examples:

2	1 sig fig
40	ambiguous, could be 1 or 2 sig figs (use scientific notations)
4.0×10^1	2 significant figures
0.0031	2 significant figures
3.03	3 significant figures

See text : 1-7

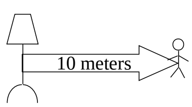
Significant Figures

- When multiplying or dividing, the answer should have the same number of significant figures as the least accurate of the quantities in the calculation.
- When adding or subtracting, the number of digits to the right of the decimal point should equal that of the term in the sum or difference that has the smallest number of digits to the right of the decimal point.
- Examples:
  - $2 \times 3.1 = 6$
  - $4.0 \times 10^1 / 2.04 \times 10^2 = 1.6 \times 10^{-1}$
  - $2.4 - 0.0023 = 2.4$

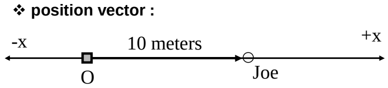
End of Chapter 1

Motion in One-Dimension (Kinematics)
Position / Displacement

- **Position is measured and referenced to an origin:**

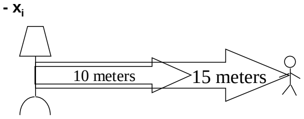


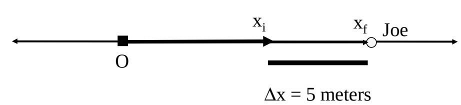
- **Joe is 10 feet to the right of the lamp**
- **origin = lamp**
- **direction = to the right**
- **position vector :**



Position / Displacement

- **Displacement is just change in position.**
  - $\Delta X = x_f - x_i$





Average speed and velocity
Changes in position *vs* Changes in time

- Average velocity = total distance covered per total time,

$$\bar{v}(\text{average velocity}) = \frac{\Delta x(\text{total displacement})}{\Delta t(\text{total time})}$$

- Speed is just the magnitude of velocity.
  - The "how fast" without the direction.

Active Figure 1 http://www.phy.ntnu.edu.tw/ntnujava/main.php?t=282

- Instantaneous velocity, velocity at a given instant

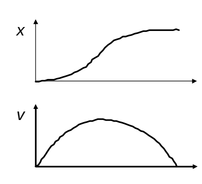
$$v(\text{velocity}) = \lim_{\Delta t \to 0} \frac{\Delta x(\text{displacement})}{\Delta t(\text{time})} = \frac{dx}{dt}$$

Active Figure 2 http://www.phy.ntnu.edu.tw/ntnujava/main.php?t=230

Recap

- If the position x is known as a function of time, then we can find both velocity v

$$x = x(t)$$
$$v = \frac{dx}{dt}$$
$$x = \int_{t_0}^{t_1} dt\ v(t)$$



Recap of today's lecture

- Measurement and units (chapter 1)
  - ❖ Systems of units (Text: 1.1)
  - ❖ Density (Text: 1.3)
  - ❖ Converting between systems of units (Text: 1.5)
  - ❖ Dimensional Analysis (Text: 1.4)
  - ❖ Position and displacement
  - ❖ Velocity and speed
- Reading for Wednesday's class 9/13/06:
  - » All of Chapter 2
  - » Chapter 3.1, 3.2
  - » Begin WebAssign Homework #1: