Physics 151, Sections: 01 - 05

Physics for Engineers - I

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Lecture 1

Agenda for Today :

- Course Introduction
  - Scope of the course
  - Structure of the course
  - What you need to do and the final grade
- Topic - Measurement and Units (Chapter 1)
  - Fundamental units
  - Systems of units
  - Converting between systems of units
  - Dimensional Analysis
  - Significant digits

Course Info

- **Course has several components:**
  - **Lecture:** (discussions, demos and active learning (ACTs).
  - **Reading Assignments**: from text, Serway&Jewett, Vol.1.
  - **Homework Sets**: problems from the back of the book
    - We will use WebAssign for doing HW (see next page).
  - **Review Sessions: If needed**
  - **Labs:** (group exploration of physical phenomena).

HOMEWORKS

- **Homework** will be processed on the web using WebAssign
- Each student will register to get his/her account (~$ 25)

- **GO TO:** **http://www.webassign.net** to register:
  - ID: Same as UConn e-mail address without @uconn.edu, e.g. JOHN.S.ANDERSON@UCONN.EDU becomes JOHN.S.ANDERSON
  - **Institution:** UConn
  - **Password:** your PeopleSoft ID

  If you have problem registering contact physics office or me
- HW will be due Friday before the weekend
- No Late HW accepted

HELP: **Become familiar with the *Physics Resource Center* for help with problem sets. Room P207-C.**

Announcements

- Most of the info about the class will be posted on:
  - http://www.phys.uconn.edu/~nkd/151_2006/
  - lecture notes (.pdf formats)
    - » homework assignments and solutions
    - » example exams
    - » syllabus

- **Labs** start week of Sept. 11
  - Lab classes are held in P204.
  - The lab manuals are on sale at the UConn Coop
    Cost - $ 12.

Exams

2 Midterms (in-class) and a Final Exam.

» Questions on tests will look like those we do in the class and in homeworks

» No surprises

Final Grade

- Homework –> 15%
- Lab Grade – > 20%
- 2 Midterms – > 30%
- Final Exam – > 35%

Scope of Physics 151

- **Classical Mechanics:**
  - **Mechanics:** How and why things work.
    motion, balance, energy, vibrations
  - **Classical:**
    - » Not too fast (v << c)
    - » Not too small (d >> atom)
- **Thermodynamics (Intro)**

- Most everyday situations can be described in these terms.
  - Path of baseball
  - Orbit of planets
  - Vibrations of a piano wire

See text 1.1

Standard Quantities

- The elements of substances and motion.
- All things in classical mechanics can be expressed in terms of the fundamental quantities:
  - Length L
  - Mass M
  - Time T

- Some examples of more complicated quantities:
  - Speed has the quantity of L / T (i.e. miles per hour).
  - Acceleration has the quantity of L/T^2.
  - Force has the quantity of ML / T^2 (as you will learn).

Units

- **SI (Système International) Units:**
  - mks: L = meters (m), M = kilograms (kg), T = seconds (s)
- **British Units:**
  - L = inches, feet, miles, M = slugs (pounds), T = seconds
- We will use mostly SI units, but you may run across some problems using British units. You should know how to convert back & forth.

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}
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

- EXAMPLE:
  - What is the radius of the Earth ?

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	~ 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

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

Atomic Density

- In dealing with macroscopic numbers of atoms (and similar small particles) we often use a convenient quantity called Avogadro's Number, $N_A = 6.02 \times 10^{23}$.

- Molar Mass and Atomic Mass are nearly equal
  - 1. Molar Mass = mass in grams of one mole of the substance.
  - 2. Atomic Mass = mass in u (a.m.u.) of one atom of a substance, is approximately the number of protons and neutrons in one atom of that substance.
- Molar Mass and Atomic Mass are other units for density.

What is the mass of a single carbon atom ?

$$M(carbon) = \frac{12\,g/mol}{6 \times 10^{23}\,atoms/mol} = 2 \times 10^{-23}\ \text{g/atom}$$

Dimensional Analysis

- This is a very important tool to check your work
  - ⇐ It's also very easy!
- Example:

  Doing a problem you get the answer distance

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

  Quantity on left side = L

  Quantity on right side = $L / T \times T^2 = L \times T$
- Left units and right units don't match, so answer must be wrong !!

Lecture 1, *ACT 1*
Dimensional Analysis

- **The force (F) to keep an object moving in a circle can be described in terms of the velocity (v, dimension L/T) of the object, its mass (m, dimension M), and the radius of the circle (R, dimension L).**
  - **Which of the following formulas for *F* *could* be correct ?**

(a) $F = mvR$

(b) $F = m\left(\frac{v}{R}\right)^2$

(c) $F = \frac{mv^2}{R}$

Remember: *Force* has dimensions of ML/T²

Lecture 1, *ACT 2*

- The equation for the change of position of a train starting at $x = 0$ m is given by $x = at^2/2 + bt^3$. The dimension of the constant b must be :

A) T^{-3}

B) $L\ T^{-3}$

C) $L\ T^{-2}$

D) $L\ T^{-1}$

E) $L^{-1}\ T^{-1}$

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:
  - How many meters per second do you travel when a speedometer in your car indicates 60 mi/hr ?

Lecture 1, *ACT 3*

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. Does the car have a good gas-mileage ? (What is the MPG of the car ?)

- Useful Conversion factors:
  - 1 gallon = 4 liters
  - 1 mile = 1.61 km

See text : 1-7

Significant Figures

- The number of digits that matter 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.
  - 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
  - 4.0×10^1 2 sig figs
  - 0.0031 2 sig figs
  - 3.03 3 sig figs

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:
  - $2 \times 3.1 = 6$
  - $3.1 + 0.004 = 3.1$
  - $4.0 \times 10^{1} \div 2.04 \times 10^{2} = 1.6 \times 10^{-1}$

Recap of today’s lecture

- Measurement and Units (Chapter 1)
  - Systems of units (Text: 1.1)
  - Density (Text: 1.3)
  - Dimensional Analysis (Text: 1.4)
  - Converting between systems of units (Text: 1.5)
  - Estimates and Order of magnitude calc. (Text: 1.6)
  - Significant figures (Text; 1.7)

- Reading for next class :
  - » Chapter 2: pages 23-46