PHYS 1441 – Section 004
Lecture #2

Monday, Jan. 26, 2004
Dr. Jaehoon Yu

- Chapter one
  - Uncertainties and Significant Figures
  - Standards and units
  - Estimates
  - Unit conversions
- Chapter two
  - Fundamentals
  - Velocity and Speed (Average and instantaneous)
  - Acceleration

Announcements

- Reading assignment #2: Read and follow through Appendix sections by Monday, Feb. 2
  - A-5, A-6, A-7, A-8 and A-9
- There will be a quiz on Wednesday, Jan. 28
- Homework Registration: 42/65 (15 of you submitted it)
  - You **must** download, print, solve and submit electronically your homework to obtain 100% credit for homework #1
  - Homework #1 due 1pm, Wednesday, Jan. 28
  - Roster will close Wednesday, Jan. 28
- E-mail distribution list (phys1441-004-spring04)
  - 18 of you subscribed as of 10am this morning
  - **5 points** extra credit if done by 6pm today, Jan. 26
  - **3 points** extra credit if done by 6pm Wednesday, Jan. 28
  - **1 point** extra credit if done by 6pm Monday, Feb. 2

PHYS 1441 sec 004 CLASS ROLL			1/21/2004	Homework registration	e-mail		
	Last Name	First Name					
	Ahmed	Iqbal		1/22/2004			
4557	Awe,	Ayodeji		1/28/2004	1/28/2004		
2904	Barajas	Graciela					
7025	Bazzazadegan,	Tiffany		1/22/2004	1/22/2004		
2301	Bergman,	Timothy					
3908	Biber,	Karl		1/22/2004	1/22/2004		
458	Bishop,	Candace		1/22/2004			
2239	Blackmon,	Adam		1/22/2004			
567	Buckley,	Michael		1/22/2004			
1733	Caldwell,	Amanda		1/22/2004	1/22/2004		
3727	Canty,	Chandra		1/22/2004			
1452	Carr,	Paul		1/22/2004			
9193	Chavez,	Debra		1/22/2004	1/22/2004		
2304	Coates,	Elizabeth		1/22/2004	1/22/2004		
3483	Conley,	Arthur		1/26/2004	1/26/2004		
3200	Cooper,	Lance					
3954	Cronan,	James					
9750	Crouse,	Jennifer		1/22/2004			
3087	Cumplan,	Lightman					
8110	Do,	Tuan		1/22/2004			
2559	Fitch,	Michelle		1/22/2004			
4315	Floyd	Jennifer					
9333	Gaskill,	Katherine			1/26/2004		
2535	Godfrey,	William					
3598	Gonzales,	Karen		1/22/2004			
3748	Gaurd,	Hiren					
1652	Ha,	Tuong					
1933	Hall,	Anthony					
234	Hatchill,	Kathryn		1/28/2004			
3552	Hile,	Jared					
9055	Lac,	Anh					
9338	Larkin,	Erin		1/22/2004	1/22/2004		
5598	Le,	Lan		1/26/2004			
5555	Le,	Steven		1/26/2004	1/26/2004		
4727	Lee,	Ji Young		1/22/2004			
4131	Leiney,	Kristin		1/22/2004			
2214	McAlister,	Micah		1/28/2004	1/24/2004		
7648	McCammon,	Kelly		1/22/2004	1/22/2004		
1746	Mickelthen,	Jessica		1/22/2004	1/28/2004		
3239	Medina,	Jason		1/28/2004			
5973	Melendez,	Jaqueline					
1835	Mellar,	Toni					
4472	Newby,	Jerry		1/26/2004			
5171	Parikh,	Andrea		1/26/2004			
5783	Parmer,	Kerri		1/22/2004			
6564	Patel,	Meena		1/22/2004	1/26/2004		
3552	Paulk,	Nida		1/22/2004			
2819	Person,	Joshua		1/22/2004			
4757	Pham,	Hanh					
4746	Pope,	Angela					
6105	Price,	Michael					
3538	Quinn,	Victoria		1/28/2004	1/28/2004		
4504	Ratz,	Stephen					
3357	Rawls,	Tiffany					
1041	Rios,	Guadalupe					
5438	Robinson,	Ashley		1/26/2004			
2130	Skinner,	Bryan		1/22/2004			
6168	Smith,	O Iwena		1/22/2004			
2300	Starks,	Jason					
4905	Tumlinson,	Jay		1/26/2004			
5161	Vergara,	Jaime		1/22/2004	1/28/2004		
2521	Vigliano,	Katherine		1/26/2004			
2392	West,	Michael					
6768	Williams,	Felina		1/22/2004	1/22/2004		

Uncertainties

- Physical measurements have limited precision, however good it is, due to:
  - Stat.{ – Number of measurements
  - Syst.{ – Quality of instruments (meter stick vs micro-meter)
  - – Experience of the person doing measurements
  - – Etc
  - In many cases, uncertainties are more important and difficult to estimate than the central (or mean) values

Why and when do uncertainties matter?

Significant Figures

- Significant figures denote the precision of the measured values
  - Significant figures: non-zero numbers or zeros that are not place-holders
    - 34 has two significant digits, 34.2 has 3, 0.001 has one because the 0's before 1 are place holders, 34.100 has 5, because the 0's after 1 indicates that the numbers in these digits are indeed 0's.
    - When there are many 0's, use scientific notation:
      - $31400000=3.14\times10^{7}$
      - $0.00012=1.2\times10^{-4}$

Significant Figures

- Operational rules:
  - Addition or subtraction: Keep the <u>smallest number of decimal place</u> in the result, independent of the number of significant digits: 34.001+120.1=154.1
  - Multiplication or Division: Keep the <u>smallest significant figures</u> in the result: 34.001x120.1 = 4083, because the smallest significant figures is 4.

Needs for Standards and Units

- Basic quantities for physical measurements
  – Length, Mass, and Time
- Need a language that everyone can understand each other
  – Consistency is crucial for physical measurements
  – The same quantity measured by one must be comprehendible and reproducible by others
  – Practical matters contribute
- A system of unit called SI (*System Internationale*) established in 1960
  – Length in meters (*m*)
  – Mass in kilo-grams (*kg*)
  – Time in seconds (*s*)

Definition of Base Units

SI Units	Definitions
1 *m (Length)* = *100 cm*	One meter is the length of the path traveled by light in vacuum during a time interval of <u>1/299,792,458 of a second</u>.
1 *kg (Mass)* = *1000 g*	It is equal to the mass of the international prototype of the kilogram, made of platinum-iridium in International Bureau of Weights and Measure in France.
1 *s (Time)*	One second is the <u>duration of 9,192,631,770 periods of the radiation</u> corresponding to the transition between the two hyperfine levels of the ground state of the Cesium 133 (C^{133}) atom.

- *There are prefixes that scales the units larger or smaller for convenience (see pg. 11)*
- *Units for other quantities, such as Kelvins for temperature, for easiness of use*

Prefixes, expressions and their meanings

- deca (da): 10^{1}
- hecto (h): 10^{2}
- kilo (k): 10^{3}
- mega (M): 10^{6}
- giga (G): 10^{9}
- tera (T): 10^{12}
- peta (P): 10^{15}
- exa (E): 10^{18}

- deci (d): 10^{-1}
- centi (c): 10^{-2}
- milli (m): 10^{-3}
- micro (μ): 10^{-6}
- nano (n): 10^{-9}
- pico (p): 10^{-12}
- femto (f): 10^{-15}
- atto (a): 10^{-18}

International Standard Institutes

- International Bureau of Weights and Measure http://www.bipm.fr/
  - Base unit definitions: http://www.bipm.fr/enus/3_SI/base_units.html
  - Unit Conversions: http://www.bipm.fr/enus/3_SI/
- US National Institute of Standards and Technology (NIST) http://www.nist.gov/

How do we convert quantities from one unit to another?

Unit 1 = Conversion factor X Unit 2

1 inch	2.54	cm
1 inch	0.0254	m
1 inch	2.54×10^{-5}	km
1 ft	30.3	cm
1 ft	0.303	M
1 ft	3.03×10^{-4}	km
1 hr	60	minutes
1 hr	3600	seconds
And many	More	Here….

Examples 1.3 & 1.4

- Ex 1.3: A silicon chip has an area of 1.25in^2. Express this in cm^2.

What do we need to know?

$$1.25\ \text{in}^2 = 1.25\ \text{in}^2 \times \left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)^2$$

$$= 1.25\ \text{in}^2 \times \left(\frac{6.45\ \text{cm}^2}{1\ \text{in}^2}\right)$$

$$= 1.25 \times 6.45\ \text{cm}^2 = 8.06\ \text{cm}^2$$

- Ex 1.4: Where the posted speed limit is 65 miles per hour (mi/h or mph), what is this speed (a) in meters per second (m/s) and (b) kilometers per hour (km/h)?

$$1\ \text{mi} = (5280\ \text{ft})\left(\frac{12\ \text{in}}{1\ \text{ft}}\right)\left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)\left(\frac{1\ \text{m}}{100\text{cm}}\right) = 1609\ \text{m} = 1.609\ \text{km}$$

(a) $$65\ \text{mi/h} = (65\ \text{mi})\left(\frac{1609\ \text{m}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 29.1\ \text{m/s}$$

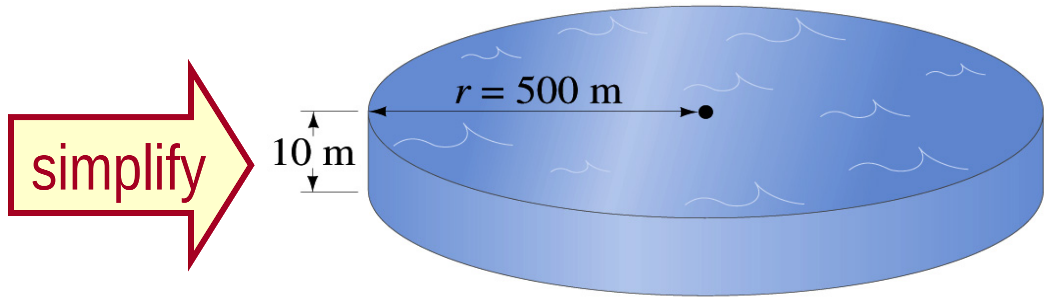
(b) $$65\ \text{mi/h} = (65\ \text{mi})\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right) = 104\ \text{km/h}$$

Estimates & Order-of-Magnitude Calculations

- Estimate = Approximation
  - Useful for rough calculations to determine the necessity of higher precision
  - Usually done under certain assumptions
  - Might require modification of assumptions, if higher precision is necessary
- Order of magnitude estimate: Estimates done to the precision of 10s or exponents of 10s;
  - Rapid estimating
  - Three orders of magnitude: 10^3=1,000
  - Round up for Order of magnitude estimate; $8\times10^7 \sim 10^8$
  - Similar terms: "Ball-park-figures", "guesstimates", etc

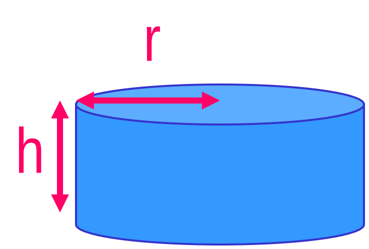
Example 1.5

Estimate how much water is in a lake in the figure which is roughly circular, about 1km across, and you guess it to have an average depth of about 10m.



Volume of a cylinder

$$V = h \times A$$
$$= h \times \pi r^2$$



What is the radius of the circle? Half the distance across… 1km/2=1000m/2=500m

$$V = h \times \pi r^2 = 10m \times \pi (500m)^2 = 7850000 \simeq 8 \times 10^6 m^3 \simeq 10^7 m^3$$

Dimension and Dimensional Analysis

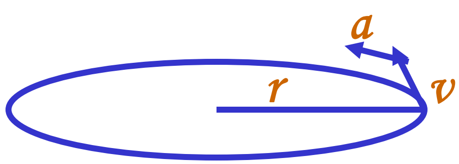
- An extremely useful concept in solving physical problems
- Good to write physical laws in mathematical expressions
- No matter what units are used the base quantities are the same
  - *Length* (distance) is length whether meter or inch is used to express the size: Usually denoted as *[L]*
  - The same is true for *Mass ([M])* and *Time ([T])*
  - One can say “Dimension of Length, Mass or Time”
  - Dimensions are used as algebraic quantities: Can perform algebraic operations, addition, subtraction, multiplication or division

Dimension and Dimensional Analysis

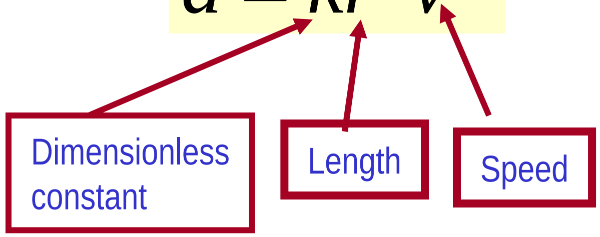
- One can use dimensions only to check the validity of one's expression: Dimensional analysis
  - Eg: Speed $[v] = [L]/[T]=[L][T^{-1}]$
    - *Distance (L) traveled by a car running at the speed V in time T*
    - $L = V*T = [L/T]*[T]=[L]$
- More general expression of dimensional analysis is using exponents: eg. $[v]=[L^nT^m] =[L]\{T^{-1}]$ *where* $n = 1$ *and* $m = -1$

Examples

- Show that the expression $[v] = [at]$ is dimensionally correct
  - Speed: $[v]$ =L/T
  - Acceleration: $[a]$ =L/T^2
  - Thus, $[at]$ = (L/T^2)xT=LT$^{(-2+1)}$ =LT^{-1} =L/T= $[v]$
- Suppose the acceleration a of a circularly moving particle with speed v and radius r is proportional to r^n and v^m. What are n and m?



$$a = kr^n v^m$$



$$L^1T^{-2} = (L)^n\left(\frac{L}{T}\right)^m = L^{n+m}T^{-m}$$

$$-m = -2 \Rightarrow \boldsymbol{m = 2}$$

$$n + m = n + 2 = 1 \Rightarrow \boldsymbol{n = -1}$$

$$a = kr^{-1}v^2 = \frac{v^2}{r}$$

Some Fundamentals

- Kinematics: Description of Motion without understanding the cause of the motion
- Dynamics: Description of motion accompanied with understanding the cause of the motion
- Vector and Scalar quantities:
  - Scalar: Physical quantities that require magnitude but no direction
    - Speed, length, mass, etc
  - Vector: Physical quantities that require both magnitude and direction
    - Velocity, Acceleration, Force, Momentum
    - It does not make sense to say "I ran with velocity of 10miles/hour."
- Objects can be treated as point-like if their sizes are smaller than the scale in the problem
  - Earth can be treated as a point like object (or a particle)in celestial problems
  - Any other examples?