PHYS 1443 – Section 501
Lecture #1

Monday, Jan. 14, 2002
Dr. Jaehoon Yu

1. Basic Information and Organization
2. What is Physics?
3. What do we want from this class?
4. Standard Units
5. Building Blocks of Matter
6. Dimension and Dimensional Analysis
7. Significant Figures and Uncertainties

Who am I?

- Name: Dr. Jaehoon Yu (You can call me **Dr. Yu**)
- Office: Rm 242, Science Hall
- Extension: x2814, E-mail: *jaehoonyu@uta.edu*
- My profession:High Energy Physics
  - Collide particles (protons on anti-protons or electrons on anti-electrons, positrons) at the energies equivalent to 10,000 Trillion degrees
  - To understand
    - Fundamental constituents of matter
    - Interactions or forces between the constituents
    - Creation of Universe (**Big Bang** Theory)
  - A pure scientific research activity
    - Direct use of the fundamental laws we find may take longer than we want but
    - Indirect product of research contribute to every day lives; eg. WWW

Information & Communication Source

- My web page: http://www-hep.uta.edu/~yu/
  - Contact information & Class Schedule
  - Syllabus
  - Holidays and Exam days
  - Evaluation Policy
  - Class Style & homework
  - Contact Information
  - Other information
- Would like a PHYS1443-501 e-mail distribution list for fast and efficient communication.   Any volunteer?

Course Specification for 1443 - 501, Spring 2002 - Microsoft Internet Explorer

Address http://www-hep.uta.edu/~yu/spring02-1443-501.html

Course Specification for 1443-501, Spring 2002

Class Schedule	5:30 - 6:50pm Mondays & Wednesdays Room 125, Science Hall
Instructor	Dr. Jaehoon Yu
Office	Room 242, Science Hall Phone: (817) 272 - 2814 Secretary: (817) 272 - 2811
Office Hours	11:00am - 12:00pm Mondays and Wednesdays
Prerequisites	MATH 1426 or concurrent enrollment. You must enroll in a lab section ($8.00 fee), unless exampted.
Textbook	Physics for Scientists and Engineers, 5th Edition Serway & Beichner Saunders College Publishing

- Lecture Notes
- Syllabus
- Holidays & Exam Days
- Evaluation Policy
- Class Style & Home Work Assignments
- Contact Information
- Other Information

Syllabus for PHYS 1443 - 501, Spring 2002 - Microsoft Internet Explorer

Address: http://www-hep.uta.edu/~yu/spring02-1443-501/syllabus.html

Syllabus for1443-501, Spring 2002

Period	Chapters
Weeks of Jan. 14 & Jan. 21, 2002	One & Two Dimensional Motion (No class on Martin Luther King's day, Monday, Jan. 21, 2002)
Weeks of Jan. 28 & Feb. 04, 2002	Newton's Law of Motion, Circular Motion & Kinetic Energy
Monday, Feb. 11, 2002	**First Term Exam (Chap. 1-7)**
Feb. 13, 2002 & Week of Feb. 20, 2002	Energy and Momentum Conservation
Week of Feb. 25, 2002	Rotational Motion and Angular Momentum
Week of Mar. 4 & Mar. 11, 2002	Static Equilibrium and Oscillatory Motion
Wednesday, Mar. 13, 2002	**Midterm Exam (Chap 1 - 13)**
Week of Mar. 18, 2002	Spring Break
Weeks of Mar. 25 & Apr. 1, + Apr. 8, 2002	Fluid Mechanics and Mechanical Waves
Wednesday, Apr. 10, 2002	**Second Term Exam (Chap. 13 - 18)**
Week of Apr. 15, 2002	Temperature and Introduction to Thermodynamics
Week of Apr. 22, 2002	Kinetic Theory of Gas and Heat Energy
Week of Mar. 29, 2002	Review
Wednesday, May 8, 2002	**Final Exam (Chap. 1 - 18)**

***** The above schedule might change depending on the progress in the class.*

Return to Course Specification Page
Return to Jae's Home Page

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Holidays and Exam Days for PHYS 1443 - 501, Spring 2002 - Microsoft Internet Explorer

Address: http://www-hep.uta.edu/~yu/spring02-1443-501/exams-n-holidays.html

Holidays & Exam days for 1443-501, Spring 2002

Catrgory	Dates
Martin Luther King Day	Monday, Jan. 21, 2002
First Term Exam	Monday, Feb. 11, 2002
Mid-Term	Wednesday, Mar. 13, 2002
Spring Break	Mar. 18 - 22, 2002
Easter Holiday	Friday, Mar. 29, 2002
Second Term Exam	Apr. 10, 2002
State of Texas Science and Engineering Fair (No Class in College of Science only)	Friday, Apr. 12, 2002
Final Exam	Wednesday, May 8, 2002

Evaluation Policy for PHYS 1443 - 501, Spring 2002 - Microsoft Internet Explorer

Address: http://www-hep.uta.edu/~yu/spring02-1443-501/evaluation.html

Evaluation Policy for1443-501, Spring 2002

Category	Percentage Contribution
Final Exam	30%
Mid-Term	25%
Best of the remaining two Term Exams	25%
Lab Score	20%

Evaluation procedure:

- *The scores from the above four categories will be adjusted to reflect the difficulty and the performance of the classes, using the mean values of the exams.*
- *These adjusted scores will be used in the computation of the final score using the following fomula:*

*FInal Score = (Adjusted Score of the Final Exam) * 0.3*
*+ (Adjusted Score of the Mid-term Exam) * 0.25*
*+ (Adjusted Score of the best term Exam) * 0.25*
*+ (Lab Score) * 0.2*

- *Grading will then be determined using the final score, and based on its distributions.*
- *If you miss any exam* ***with*** *an understandable reason or a prior approval by me:*
  - *An individual exam needs to be arranged separately with me within a week of the exam or within the agreed time period.*
- *If you miss any exam* ***without*** *an understandable reason or a prior approval by me:*
  - *An individual exam needs to be arranged separately with me within a week of the exam or within the agreed time period.*
  - *Your score for the exam will be adjusted down to the* ***75% of the possible maximum.***
- *If you miss more than two exams, you grade will be an automatic failure.*

Done — Internet

Homework and Class Style

- Homework Assignments
  - Solving chapter problems is the only way to comprehend class material
  - Your own responsibility
  - I will go through a few selected problems in the next class as time permits
  - But it might change depending on your performances.
- Attendance is your responsibility
  - You are adults now, so you should be responsible for yourselves
- Class style:
  - Will do as much as I can in electronic media
  - Will be mixed with traditional methods
  - Questions and discussion are **STRONGLY** encouraged
- Need volunteers to take care of the projector

Why do Physics?

Exp. {
- To understand nature through experimental observations and measurements (**Research**)

Theory {
- Establish limited number of fundamental laws, usually with mathematical expressions
- Predict the nature's course

? Theory and Experiment work hand-in-hand

? Theory works generally under restricted conditions

? Discrepancies between experimental measurements and theory are good for improvements

? Improves our everyday lives, though some laws can take a while till we see amongst us

What do we want from this class?

- Physics is everywhere around you.
- Understand the fundamental principles that surrounds you in everyday lives…
- Identify what law of physics applies to what phenomena…
- Understand the impact of such physical laws
- Learn how to research and analyze what you observe.
- Learn how to express observations and measurements in mathematical language.
- Learn how to express your research in systematic manner in writing
- I don't want you to be scared of PHYSICS!!!
- It really is nothing but a description of nature in mathematical language for ease of use

Brief History of Physics

- AD 18th century:
  - Newton's Classical Mechanics: A theory of mechanics based on observations and measurements
- AD 19th Century:
  - Electricity, Magnetism, and Thermodynamics
- Late AD 19th and early 20th century (Modern Physics Era)
  - Einstein's theory of relativity: Generalized theory of space, time, and energy (mechanics)
  - Quantum Mechanics: Theory of atomic phenomena
- Physics has come very far, very fast, and is still progressing, yet we've got a long way to go
  - What is matter made of?
  - How do matters get mass?
  - How and why do matters interact with each other?
  - How is universe created?

Needs for Standards and Units

- Base 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** (*International System of units in French*) established in 1960
  - Length in meters (*m*)
  - Mass in kilo-grams (*kg*)
  - Time in seconds (*s*)

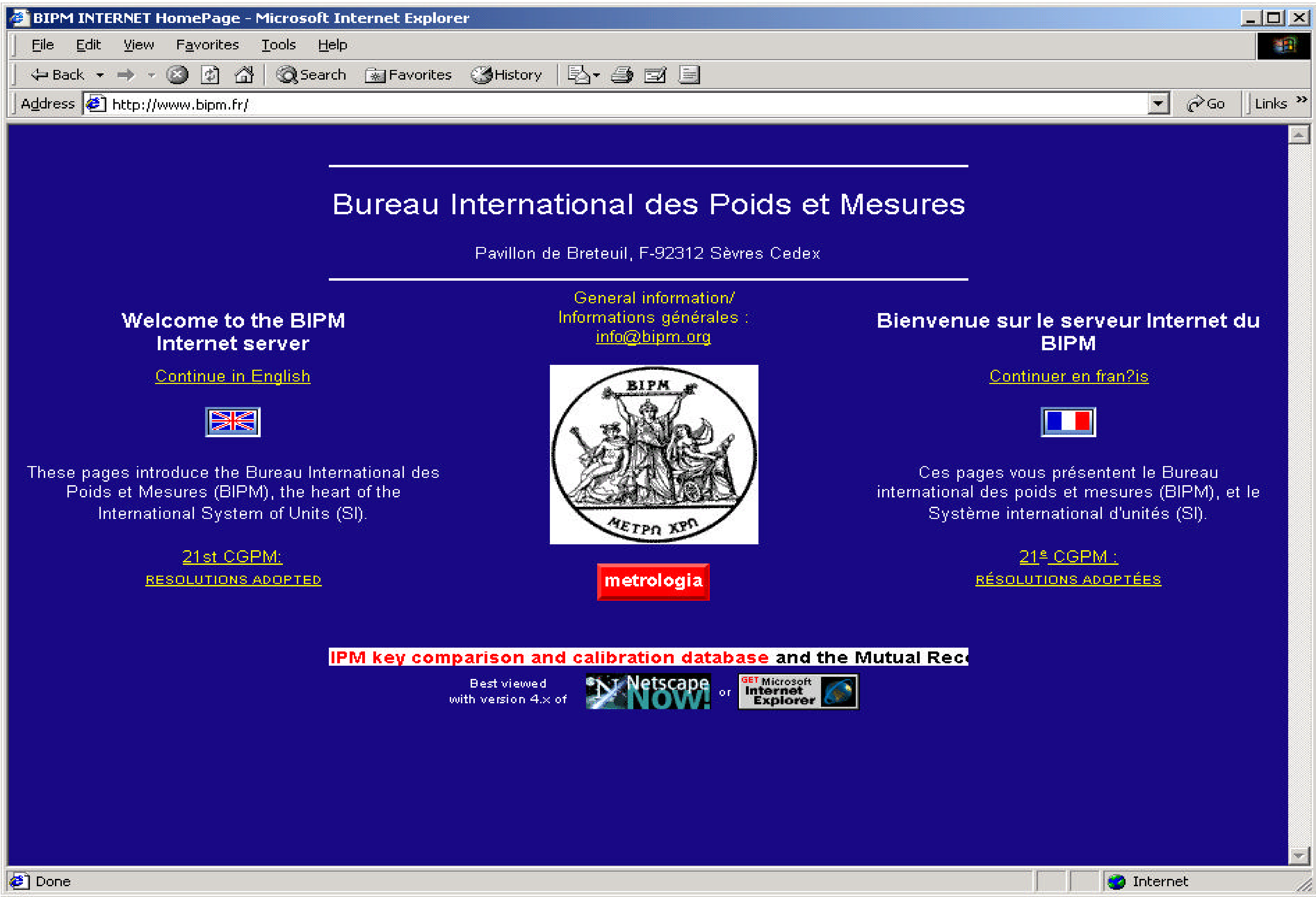
Definition of Base Units

SI Units	Definitions
1 *m (Length)* = *100 cm*	The meter is the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second.
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)*	The second is the duration of 9,192,631,770 periods of the radiation 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. 7)*
- *Units for other quantities, such as Kelvins for temperature, for easiness of use*

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/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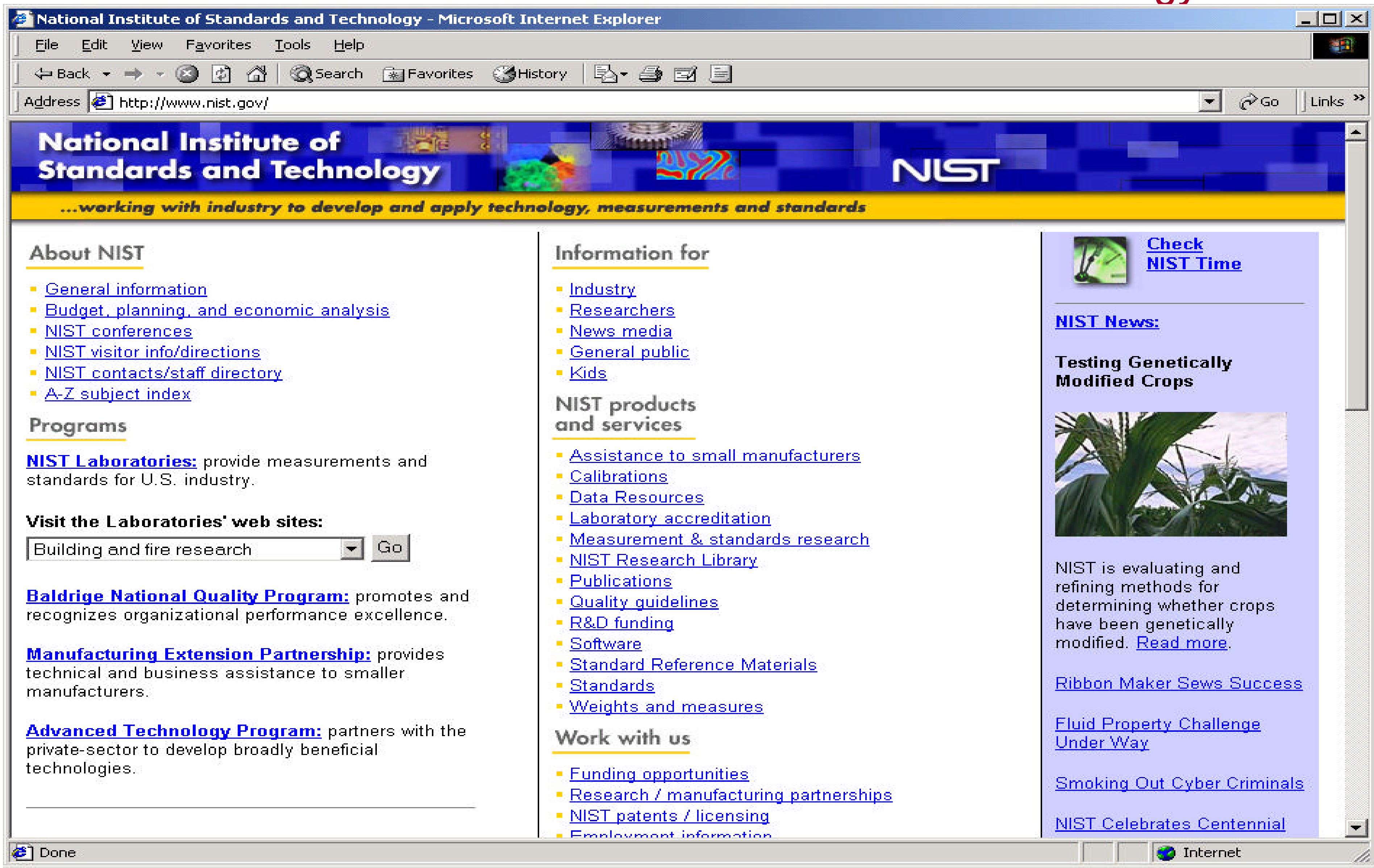


Building Blocks of Matters, Density, and Avogadro's Number

- Matter can be sliced to its fundamental constituents
  - Matter ✍ Molecule ✍ Atom ✍ Nucleus ✍ Protons and Neutrons ✍ Quarks
    - Atomic number (ID) of a substance = Number of Protons
    - Substances with the same Atomic number but different mass exist in nature and are called **Isotopes**
    - Atomic mass of a substance = average N_p+N_n of all isotopes
- A property of matter is density of matter (?): Amount of mass contained within unit volume (e.g.: $?_{Al}=2.7 g/cm^3$)

$$? \; ? \; \frac{M(kg)}{V(m^3)}$$

- One *mole (mol)* of a substance ✍ Definition of a standard for consistency
  - The amount of the substance that contains as many particles (atoms, molecules, etc) as there are in 12g of C^{12} Isotope
  - This number, based on experiment, is:
    - Avogadro's number: 6.02×10^{23} particles/mol

Example 1.1

- A cube of *Al* whose volume V=0.2 *cm*³
  - Density: ? = 2.7 *g/cm*³
- What is the number of Al atoms contained in the cube?

1. What is the mass of the cube?

$$m ? \; ?V \; ? \; 2.7(g/cm^3) ? 0.2(cm^3) \; ? \; 0.54(g)$$

2. What is the mass of 1 mol of Al?

$$m_{Al} \; ? \; 27(g/mol) \; ? \; 27g/6.02 ? 10^{23}(atoms)$$

3. So using proportion:
   - 27*g* : 6.02x10²³(atoms) = 0.54*g* : N(atoms)

$$N \; ? \; \frac{m}{m_{Al}} \; ? \; \frac{0.54g}{27(g/mol)} \; ? \; 0.02mol$$

$$? \; 0.02 ? 6.02 ? 10^{23}(atoms) \; ? \; 1.2 ? 10^{22}(atoms)$$

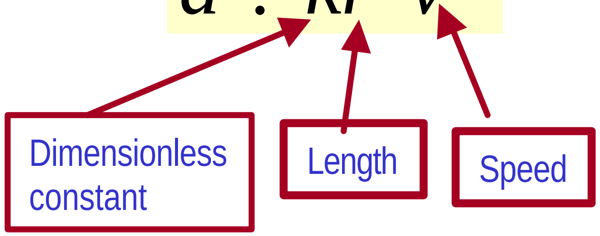
Dimension and Dimensional Analysis

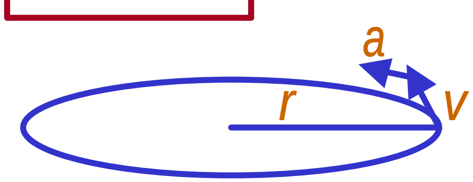
- An extremely useful concept in solving physical problems
- Good to write physical laws in mathematical expressions
- No matter what units are used the base quantities are the same
  - *Length* (distance) is length whether meter or inch is used to express the size: Usually denoted as *[l]*
  - The same 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
- One can use dimensions only to check the validity of one's expression: Dimensional analysis
  - Eg: Speed $[v] = [l]/[t]$
    - *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. $[v]=[l^n t^m]$ *where* $n = 1$ *and* $m = -1$

Examples 1.2 & 1.3

- 1.2: Show that the expression *[v] = [at]* is dimensionally correct
  - Based on table 1.6
    - Speed: *[v]* =L/T
    - Acceleration: *[a]* =L/T^2
    - Thus, *[at]* = (L/T^2)xT=LT$^{(-2+1)}$ =LT^{-1} =L/T= *[v]*
- 1.3: Suppose *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*?

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





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

$$-m = -2$$

$$m = 2$$

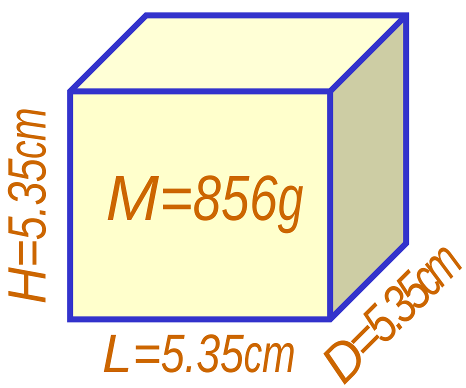
$$n + m = n + 2 = 1$$

$$n = -1$$

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

Unit Conversion: Example 1.4

- US and UK still use British Engineering units: foot, lbs, and seconds
  - 1.0 in= 2.54 cm, 1ft=0.3048m=30.48cm
  - 1m=39.37in=3.281ft~1yd, 1mi=1609m=1.609km
  - 1lb=0.4535kg=453.5g, 1oz=28.35g=0.02835kg
  - Online unit converter: http://www.digitaldutch.com/unitconverter/
- Example 1.4: Determine density in basic SI units (*m,kg*)



$$\rho = \frac{M}{V}$$

$$V = L \times D \times H = (5.35\,cm) \times (5.35\,cm) \times (5.35\,cm) = (5.35)^3\,cm^3$$

$$= 153.13\,cm^3 = \frac{153.13\,cm^3}{(100\,cm/m)^3} = 153.13 \times 10^{-6}\,m^3$$

$$M = 856\,g = \frac{856\,g}{1000\,g/kg} = 0.856\,kg$$

$$\rho = \frac{M}{V} = \frac{0.856\,kg}{153.13 \times 10^{-6}\,m^3} = 5.59 \times 10^3\,kg/m^3$$

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;
  - 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

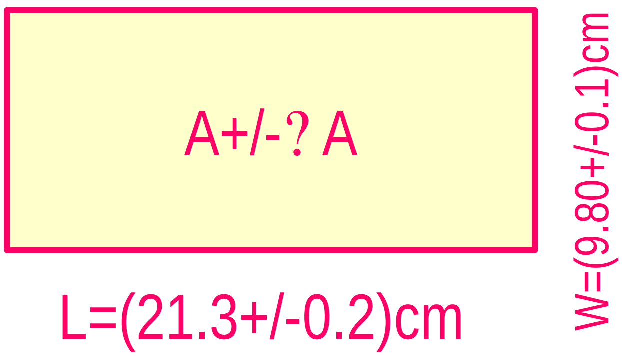
- Perform an order of magnitude estimate number of breaths taken during an average life span:
  - Assumption #1: Average life span = 70 years
  - Assumption #2: Average number of breath taken per minute: 10breath/minute, disregarding any other possibilities of variation
  - ? Total number of minutes in an average life span =70(yr)x400(days/yr)x25(hrs/day)x60(min/hr)=4×10^{7} (min)
  - ? Total number of breath taken in a life span =4×10^{7}(min)x10(breath/min) = 4×10^{8} (breaths)
  - ? Think about possible ways to improve this estimate.

Uncertainties and Significant Figures

- Physical measurements have limited precision, however good it is, due to:
  - Syst.{ – Quality of instruments (meter stick vs micro-meter)
  - – Experience of the person doing measurements
  - Stat.{ – Number of measurements
  - Etc
  - In many cases, uncertainties are more important and difficult to estimate than the central (or mean) values
- Significant figures denote this 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.
  - Operational rules:
    - Addition or subtraction: Keep the smallest number of **decimal place** in the result, independent of the number of significant digits: 34.001+120.1=154.1
    - Multiplication or Division: Keep the smallest **significant figures** in the result: 34.001x120.1 = 4083, because the smallest significant figures is 4.

Example 1.8

- Area of a rectangle and the uncertainty:



1. Find the minimum:

A_{Low}=(L-? L)x(W-? W)
= (21.1 cm)x(9.7cm) = 205 (round-up)

2. Find the maximum:

A_{High}=(L+? L)x(W+? W)
= (21.5 cm)x(9.9cm) = 213 (round-up)

3. Take the average between minimum and maximum:

<A>=(A_{low+} A_{high})/2=209(cm^2)

4. Take the difference between either min or max to <A> is the uncertainty ? A: ? A=+/-4cm^2

5. Thus the result is: A=<A>+/- ? A=(209+/-4) cm^2