PHYS 1441 – Section 501
Lecture #1

Wednesday, June 2, 2004

Dr. Jaehoon Yu

- Who am I?
- How is this class organized?
- What is Physics?
- What do we want from this class?
- Brief history of physics
- Chapter one
  - Uncertainties and Significant Figures
  - Standards and units
  - Estimates
  - Unit conversions

Today's homework is homework #1, due 6pm, next Wednesday!!

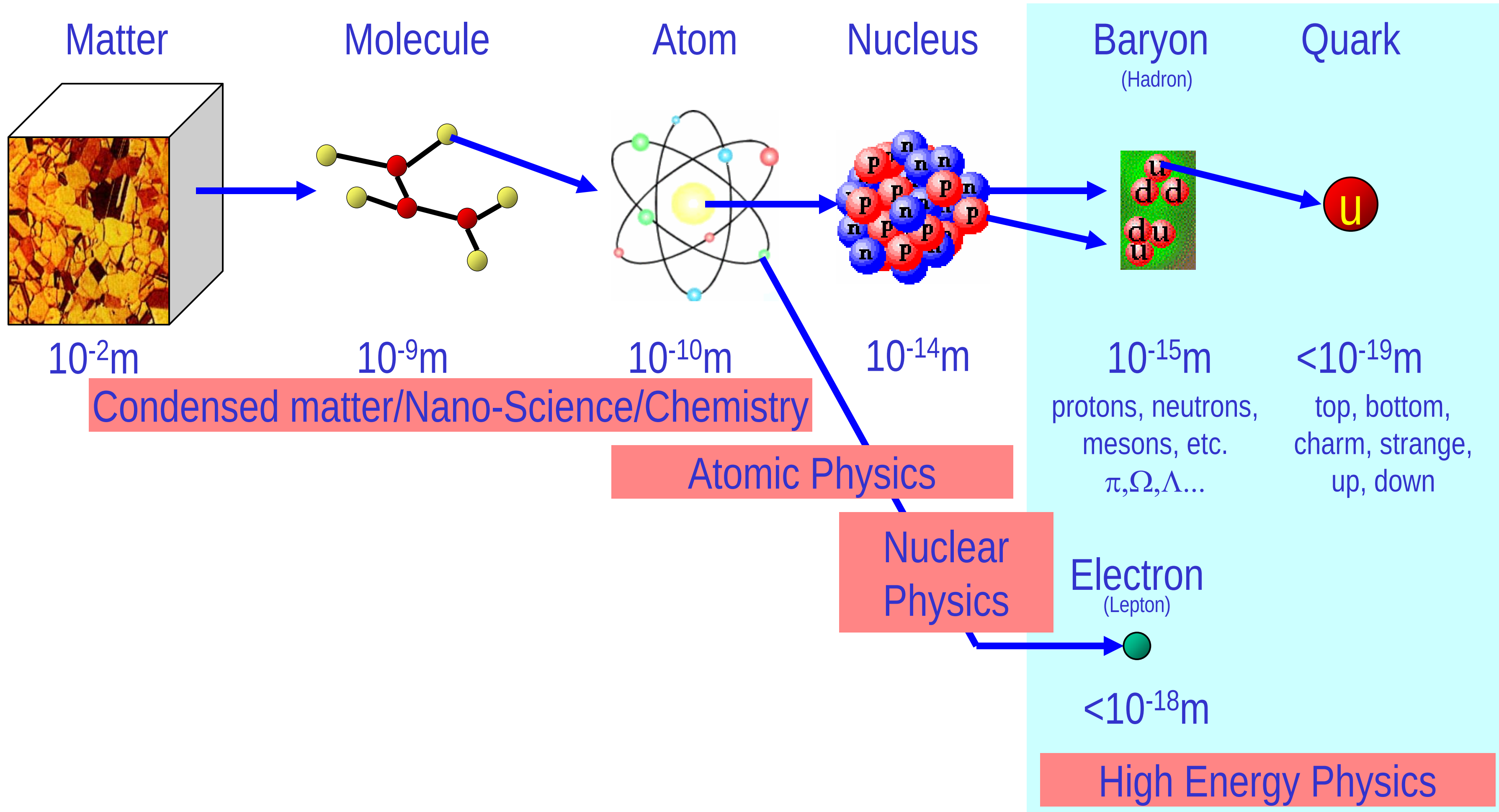
Announcements

- Reading assignment #1: Read and follow through all sections in appendix A by Wednesday, June 9
  - A-1 through A-9
- There will be a quiz on Wednesday, June 9, on these

Who am I?

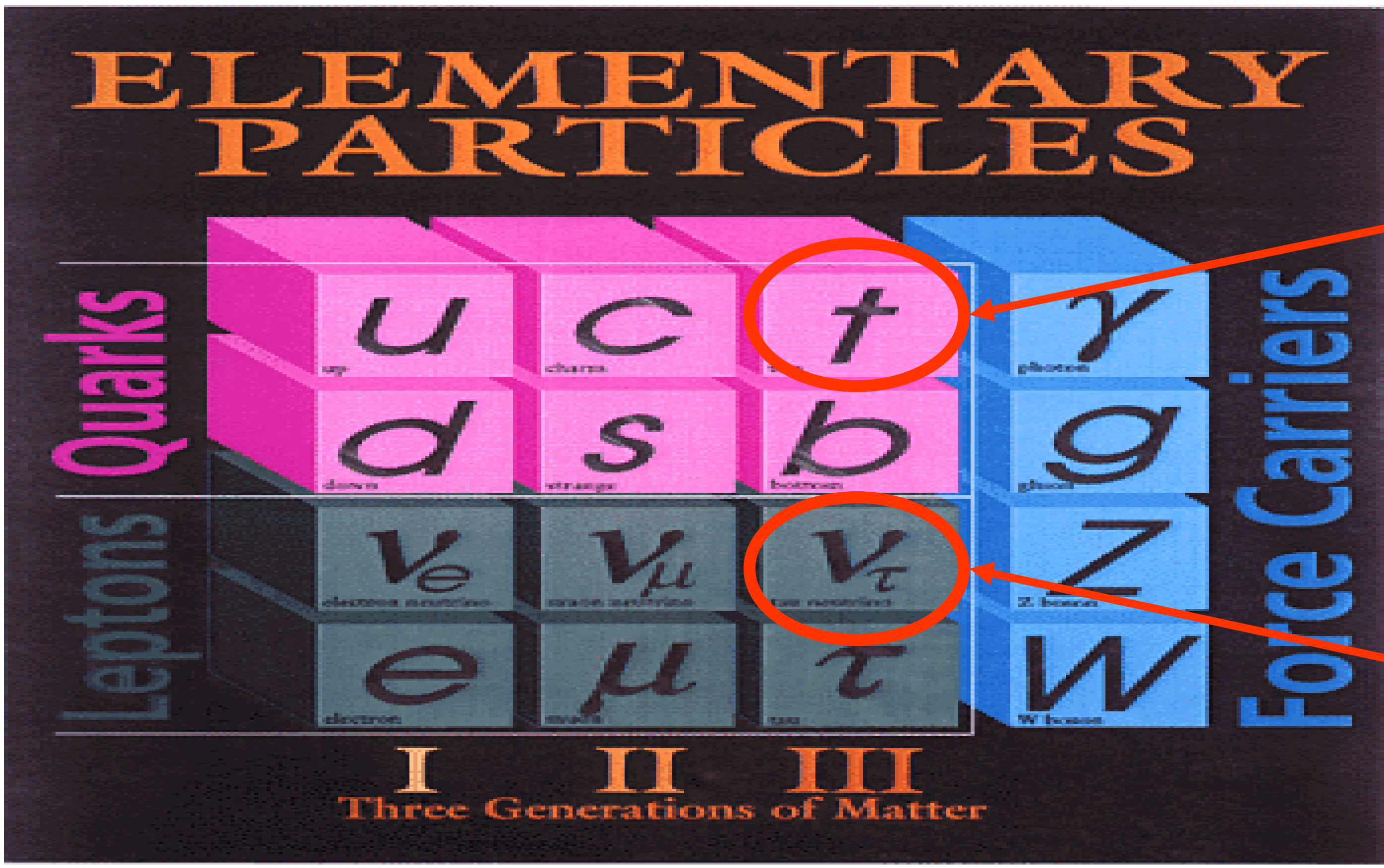
- Name: Dr. Jaehoon Yu (You can call me Dr. Yu)
- Office: Rm 242A, Science Hall
- Extension: x22814, E-mail: *jaehoonyu@uta.edu*
- My profession:High Energy Physics (HEP)
  - Collide particles (protons on anti-protons or electrons on anti-electrons, positrons) at the energies equivalent to 10,000 Trillion 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

Structure of Matter



The Standard Model

- Assumes the following fundamental structure:



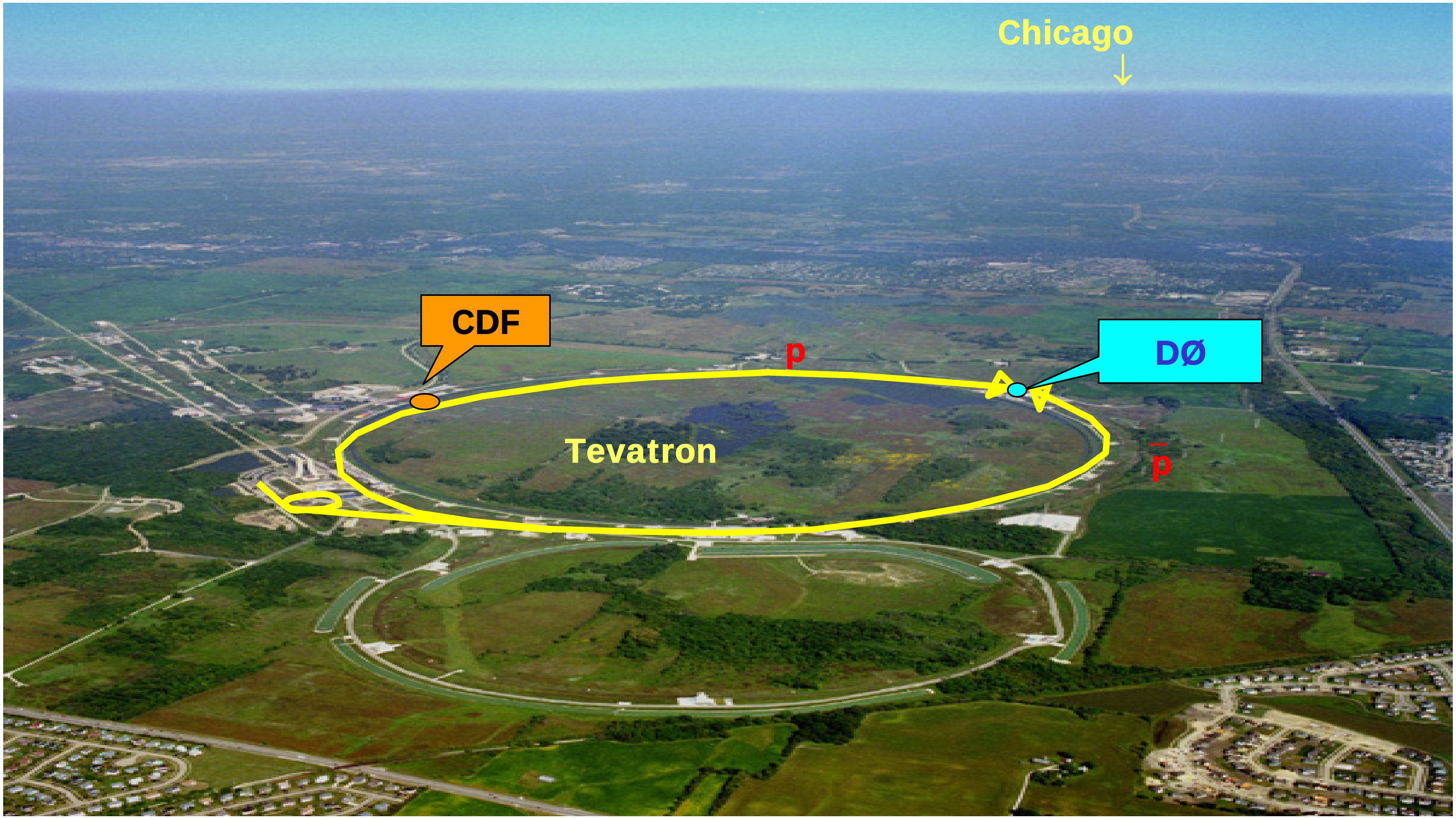
Discovered in 1995

Directly observed in 2000

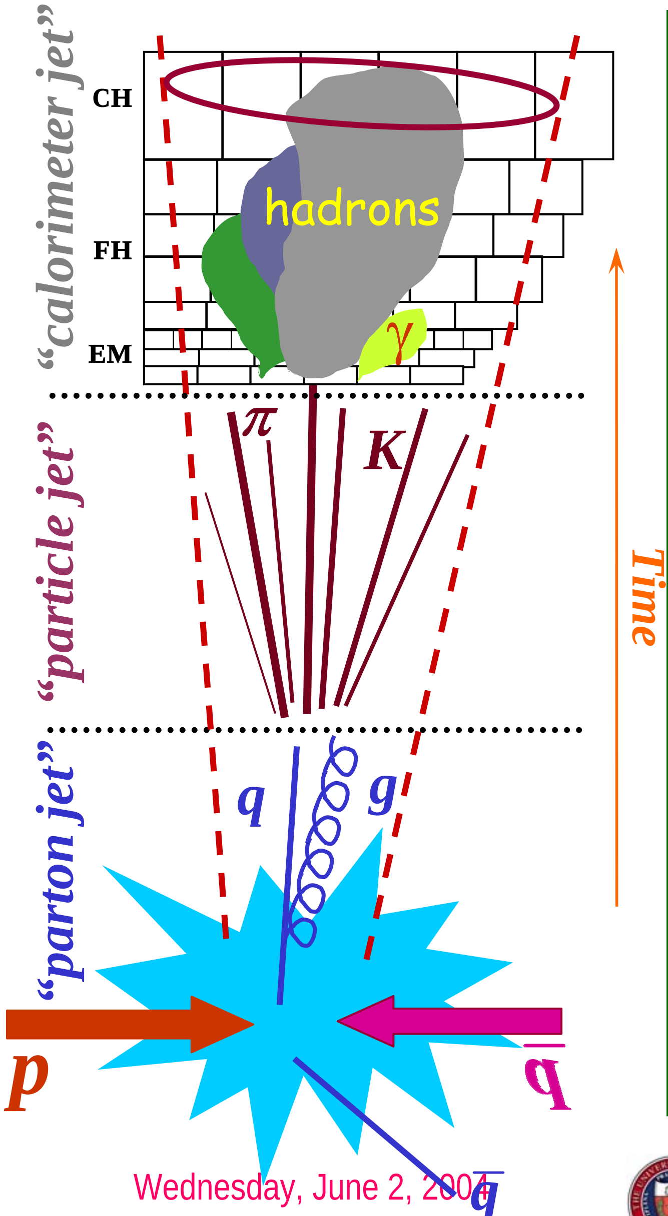
DØ Experiment at Fermilab Tevatron

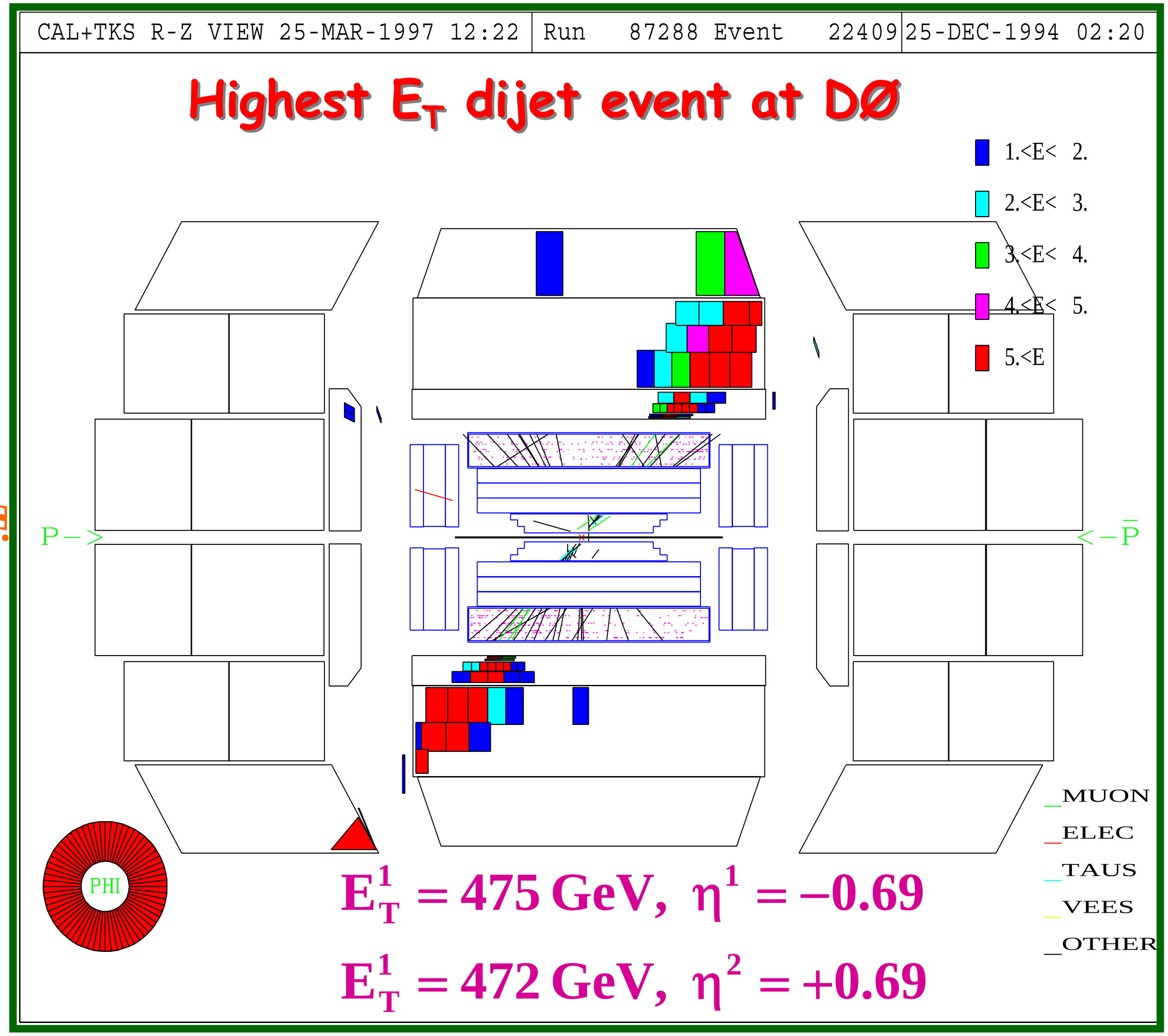
- World's Highest Energy proton-anti-proton collider
  - E_{cm}=1.96 TeV (=6.3x10^{-7}J/p ➔ 13M Joules on $10^{-6}$$m^2$)

⇒Equivalent to the kinetic energy of a 20t truck at a speed 80 mi/hr



How does an Event Look in a Collider Detector?





Information & Communication Source

- My web page: http://www-hep.uta.edu/~yu/
  - Contact information & Class Schedule
  - Syllabus
  - Homework
  - Holidays and Exam days
  - Evaluation Policy
  - Class Style & Communication
  - Other information
- Primary communication tool is e-mail: Register for PHYS1441-501-SUMMER04 e-mail distribution list as soon as possible → Instruction available in Class style & Communication
  - 5 points extra credit if done by next Monday, June 7
  - 3 points extra credit if done by next Wednesday, June 9
- Office Hours: 5:00 – 6:00pm, Mondays and Wednesdays or by appointments

Evaluation Policy

- Term Exams: 45%
  - Total of three term exams (6/23, 7/19 & 8/11)
  - Best two of the three will be chosen
  - Each will constitute 22.5% of the total
  - Missing an exam is not permissible unless pre-approved
    - No makeup test
    - You will get an F if you miss any of the exams without a prior approval
- Lab score: 20% → You must be enrolled in an 11 wk section!
- Homework: 20%
- Pop-quizzes: 15%

100%

- Extra credits: 10% of the total
  - Random attendances
  - Strong participation in the class discussions
  - Other many opportunities
- Will be on sliding scale unless everyone does very well

Homeworks

- Solving homework problems is the only way to comprehend class material
- An electronic homework system has been setup for you
  - Details are in the material distributed today and on the web
  - https://hw.utexas.edu/studentInstructions.html
  - Download homework #1 (1 problem), attempt to solve it, and submit it → You will receive a 100% credit for HW#1
  - Roster will close next Wednesday, June 9
- Each homework carries the same weight
- The worst one of the homework scores will be dropped
- Home work will constitute 20% of the total → A good way of keeping your grades high
- Strongly encouraged to collaborate → Does not mean you can copy

Attendances and Class Style

- Attendances:
  - Will be taken randomly
  - Will be used for extra credits
- Class style:
  - Lectures will be on electronic media
    - The lecture notes will be posted on the web AFTER each class
  - Will be mixed with traditional methods
  - Active participation through questions and discussions are STRONGLY encouraged → Extra credit….

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

Models, Theories and Laws

- Models: A kind of analogy or mental image of a phenomena in terms of something we are familiar with
  - Often provides insights for new experiments and ideas
- Theories: More systematically improved version of models
  - Can provide quantitative predictions that are testable and more precise
- Laws: Certain concise but general statements about how nature behaves ➔ The statement must be found experimentally valid
- Principles: Less general statements of how nature behaves
  - Has some level of arbitrariness

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 and use them appropriately
- 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 languages.
- Learn how to express your research in systematic manner in writing
- I don't want you to be scared of PHYSICS!!!

Most of importantly, let us to have a lot of FUN!!

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?

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

Uncertainties cont'd

- Estimated Uncertainty
  - Suppose a result of a measurement is expressed as

$$5.2 \pm 0.1cm$$

  - The estimated uncertainty is 0.1cm.
- Percent Uncertainty: Simply the ratio of the uncertainty to the measured value multiplied by 100:

$$\frac{0.1}{5.2} \times 100 = 2\%$$

- If uncertainties are not specified, it is assumed to be one or two units of the last digit specified:
  - For length given as 5.2cm, the uncertainty is assumed to be about 0.1cm

Significant Figures

- Significant figures denote the precision of the measured values or the number of reliably known digits
  - 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 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)*	One 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. 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 $1.25 in^2$. 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) $$65\ \text{mi/h} = (65\ \text{mi})\left(\frac{1609\ \text{m}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 29.1\ \text{m/s}$$

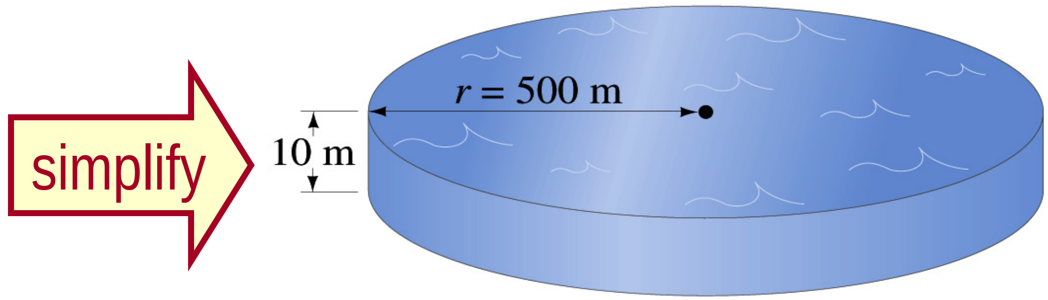
(b) $$65\ \text{mi/h} = (65\ \text{mi})\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right)\left(\frac{1}{1\ \text{h}}\right) = 104\ \text{km/h}$$

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

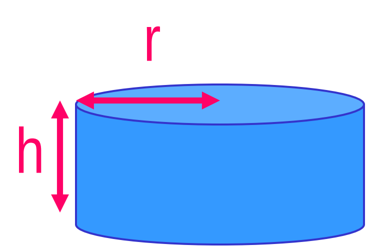
Example 1.5

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

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

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?

Some More Fundamentals

- Motions:Can be described as long as the position is known at any time (or position is expressed as a function of time)
  - Translation: Linear motion along a line
  - Rotation: Circular or elliptical motion
  - Vibration: Oscillation
- Dimensions
  - 0 dimension: A point
  - 1 dimension: Linear drag of a point, resulting in a line ➔ Motion in one-dimension is a motion on a line
  - 2 dimension: Linear drag of a line resulting in a surface
  - 3 dimension: Perpendicular Linear drag of a surface, resulting in a stereo object

Displacement, Velocity and Speed

One dimensional displacement is defined as:

$$\Delta x \equiv x_f - x_i$$

Displacement is the difference between initial and final potions of motion and is a vector quantity

Average velocity is defined as:

$$v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

Displacement per unit time in the period throughout the motion

Average speed is defined as:

$$v \equiv \frac{\text{Total Distance Traveled}}{\text{Total Time Interval}}$$

Can someone tell me what the difference between speed and velocity is?