Today:

About the course.
Why you should plan to excel in PHYS 2A

How to discover new physical laws (and to do better on exams)

Welcome to PHYS 2A!

• Physics: a general analysis of nature conducted with the goal to understand how the universe behaves.

• PHYS 2A: classical mechanics which is the study of motion of macroscopic objects (baseball, cars, rockets, planets etc.)
  - different from Quantum Mechanics, which operates at subatomic scale
  - different from Special/General Relativity, which deals with objects moving at speed close to the speed of light

• Newton’s laws and Conservation laws form the basis of classical mechanics.
Why you should plan to excel in PHYS 2A

- It's the foundation of all Science & Engineering!

- Physics teaches practical and analytical thinking like none else.

- Excellent performance in Physics will improve your prospects and financial worth in the job market.

! This is a HARD course, it will require substantial investment of your time.

About the Course

Instructor

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Schedule at a glance

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<th>MON</th>
<th>TUE</th>
<th>WED</th>
<th>THURS</th>
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<tr>
<td>Problem session 6:00 - 7:50 pm SOLIS 104</td>
<td>Lecture 11:00 am - 12:20 pm York Hall 2722</td>
<td>Discussion 7:00 - 8:50 pm PEPPER CANYON 159</td>
<td>Lecture 11:00 am - 12:20 pm York Hall 2722</td>
<td>Quiz 8:00 pm - 9:50 pm York 2722</td>
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Interplanetary spacecrafts
Laser tweezers
3D printing
iPhone accelerometer
About the course: Course website

http://dudko.ucsd.edu/physics_2a_a

It is your responsibility to check the website often.

About the course: Textbook

Richard Wolfson “Essential University Physics”, 3rd edition, Volume 1, Pearson

• Book is essential for the course!
About the course: Homework

- Problem-solving skills are crucial to your success in physics.
- The list of problems for the quarter is on the website. They are divided into Easy, Medium, and Hard.
- The problems will be worked out during Problem Sessions before the quiz.
- Do not read HW solutions until you have spent fair amount of time attempting the problems YOURSELF. Problem solving skills are acquired by doing problems, not by reading the solutions.
- Don’t give up early! Time spent doing HW is the best way to prepare for the quiz.

About the course: Quizzes and Final

- Your grade is determined by your performance on the quizzes and the final exam.
- Weekly quizzes (starting 4/12): Fri 5:00-5:50 pm, Location for section A only! → York Hall 2722
- There will be no make-up quizzes for any reason.
- Your lowest 2 quiz scores out of 9 will be dropped.
- Cumulative final exam: Tue 11 June, 11:30am-2:30pm
- It will not be possible to take the exam at any other time for any reason.
About the course: iclickers

• You receive 1 point for answering and 1 additional point for answering correctly.

• You must register the remote at www.iclicker.com

• We will start using iclickers on Tue next week.

Help is available

There is a lot of help available for you to complete your homework and understand the concepts:

• Problem Solving Sessions (starting 4/8):
  Monday 6:00 pm–7:50 pm, SOLIS 104 and Tuesday 7:00 pm–8:50 pm, Pepper Canyon 109

• Discussion Session (starting 4/10):
  Wednesday, Time & Location: refer to your schedule

• Physics Dept. Tutorial Center
  Mayer Hall 2218 http://tutorialcenter.ucsd.edu/

• Professor’s and TAs’ office hours.

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<th>Questions on:</th>
<th>Where to get help:</th>
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<td>Problem solving</td>
<td>TAs, Problem &amp; Discuss sessions, TAs’ OH</td>
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<tr>
<td>Concepts, lecture material</td>
<td>Professor’s OH</td>
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Grading

- Your grade will be calculated as:
  60% Quizzes + 40% Final + 5% Extra Credit (clickers)

- Scale (no curve!):
  
  - 100% and above => A+
  - Between 85% and 100% => A
  - Between 70% and 85%  => B
  - Between 55% and 70%  => C
  - Between 40% and 55%  => D
  - Below 40%            => F

- I want every student in this class to get an A+
  We will give you all the resources to achieve this.
  But the effort has to be yours!

Physics is a quantitative science

- “A long way” means different things to different people.

- ...Compared to what?
  Need to have a standard to quantify our measurement.

- 3 fundamental quantities:
  Time (T), Length (L), Mass (M)

- Every measurement we will make in this class can be broken up into these base quantities.

- Example: velocity can be broken up into L/T.
Measurement systems

- The most prevalent unit system in the world is SI (includes 7 independent units):
  - meters (m) <= Length [L]
  - seconds (s) <= Time [T]
  - kilograms (kg) <= Mass [M]

  Beginning 20 May 2019 (World Metrology Day), the kilogram will no longer be defined by the mass of a specific object (“artifact”); instead it will be related to Planck’s constant (h), the fundamental parameter that defines the scale of quantum mechanics.

- Other unit systems?
  - English => [feet, seconds, slugs]
  - Gaussian => [centimeters, seconds, grams]

  1 foot = 0.3 m
  1 slug = 14.6 kg

SI Prefixes

- We use prefixes to indicate multiples of the SI base units.

<table>
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<tr>
<th>Prefix</th>
<th>Exponent</th>
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<td>femto</td>
<td>10^-15</td>
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<tr>
<td>nano</td>
<td>10^-9</td>
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<tr>
<td>micro</td>
<td>10^-6</td>
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<td>milli</td>
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<td>centi</td>
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<td>kilo</td>
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<td>mega</td>
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<tr>
<td>tera</td>
<td>10^12</td>
</tr>
<tr>
<td>exa</td>
<td>10^18</td>
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Mature HIV virus

0.00000001 m = 100 nm
= 0.1 μm

SD to LA: 190,000 m = 190 km
Changing units

• Sometimes you will need to switch between units.

• Conversion factors with unit value allow you to change the units of a quantity without changing its physical value.

• Example: change 4.50 g/cm$^3$ to ?? kg/m$^3$:

$$4.50 \frac{g}{cm^3} = 4.50 \frac{g}{cm^3} \left( \frac{1 \ kg}{1,000 \ g} \right) \left( \frac{100 \ cm}{1 \ m} \right)^3 = 4,500 \frac{kg}{m^3}$$

Units mix-up => disaster

• In 1999, $327.6$ million Mars Climate Orbiter was approaching Mars...

• The Orbiter was intended to pass 147 km above the Mars surface.

• Instead reached 57 km => was destroyed by atmospheric stresses and friction at this low altitude.

• Lockheed-Martin Astronautics (spacecraft builders) used English units.

• NASA’s JPL (navigation) used SI units. Units mix-up caused crash.
**Dimensional Analysis**

How to do better on exams (and discover new physical laws)

- Dimensional analysis: you examine an equation by only looking at the dimensions and ignoring numerical values.

- Every quantity we deal with in this class can be written in terms of the base dimensions: L, M, T.

- Speed: meters per second, miles per hour, furlongs per fortnight... => it is always L/T

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**Don’t equate apples and oranges**

- Both sides of an equation must have the same dimensions for it to make sense.

- Example: Einstein’s famous formula is $E = mc^2$
  But why not $E = mc^3$?

  dimension of the mass, m: M
dimension of the speed, c: L/T
dimension of the energy, E: ML^2/T^2

- Dimensional analysis of $E = mc^3$:
  $\text{ML}^2/\text{T}^2 = \text{M(L/T)}^3 \implies \text{T} = \text{L}$
  ... dimensionally incorrect!
Dimensional Analysis

• In any given equation, you can only add like dimensions.

• Suppose you are taking an exam and you derive the following equation:
  \[ v = v_0 + \frac{1}{2}at^2 \]

• Use dimensional analysis to perform a quick check for validity:
  \[ \frac{L}{T} = \frac{L}{T} + \frac{L}{T^2} T^2 \]
  \[ \frac{L}{T} = \frac{L}{T} + L \]
  dimensionally incorrect!

Significant figures: accuracy of a number

• Significant figures of a number are those digits that carry meaning contributing to its accuracy.

• The fewer significant figures, the less accurately we can claim to know a given quantity.

Examples:

• How many sig. figures does the value 500 m have?
  1 (all non-zero digits are significant)

• 0.005 m?
  1 (leading zeros are not significant)

• 0.0050 m?
  2 (trailing zeros in a number containing a decimal point are significant)

• Results of a calculation should not convey more accuracy than the accuracy of the numbers used in the calculation.
Scientific Notation

- a compact way of writing very large or very small numbers.

**Examples:**

- Diameter of our Galaxy (Milky Way):
  
  \[800,000,000,000,000,000,000,000 \text{ m}\]
  
  or \[8 \times 10^{20} \text{ m}\]

- Mass of a raindrop: \[1 \times 10^{-6} \text{ kg}\]

- Typical human lifespan: \[2.5 \times 10^9 \text{ s}\]

- Addition/Subtraction: Give the same exponent; then add or subtract:

  \[7.46 \times 10^7 + 2.1 \times 10^6 = 7.46 \times 10^7 + 0.21 \times 10^7 = 7.67 \times 10^7\]

Estimation

- Some problems in physics and engineering call for precise numerical answers. But often we need only a rough idea of the size of a given physical effect.

- Estimate the volume of a cow:

  \[V_{\text{cow}} = \frac{4}{3} \pi R^3 \approx \]

  1. Make a rough estimate of the relevant quantities to one significant figure, preferably some power of 10.
  2. Combine the quantities to make the estimate.
  3. Think whether the estimate is reasonable.

- Every budding Scientist/Engineer/Businessperson must know how to do such estimates.
How many piano tuners are there in Chicago?

Physicist Enrico Fermi was known for his estimation prowess. At a party (late 60’s), he was approached by someone and asked: “How many piano tuners are there in Chicago?”

Solution

First we should find out how many pianos there were in Chicago...

Estimation

Solution (cont’d)

1. Fermi first estimated how many people lived in Chicago: at the time 700,000.
   • Guessed that 1 out of 3 families owns a piano.
   • A family ≈ 4 people => 1 piano per 12 people. Round this to 1 piano per 10 people for ease.
   • => about 70,000 pianos in Chicago at that time.

2. How many piano tuners could get work for 70,000 pianos?
   • It takes 1 to 2 hours to tune a piano.
   • => a piano tuner could service about 4 pianos a day.
Estimation

Answer

• Assume a typical work schedule: 5 days/week and 50 weeks/year.

• So, in a year a piano tuner will tune:

\[ (4 \text{ pianos/tuner-day}) \times (5 \text{ days/week}) \times (50 \text{ weeks/year}) \Rightarrow 1,000 \text{ pianos/(tuner-year)} \]

• A piano should be tuned about once a year

\[ \Rightarrow \]

\[ \frac{70,000 \text{ pianos/year}}{1,000 \text{ pianos/tuner-year}} = \frac{70}{70} \text{ tuners} \]

Actual listing in the phone book: 50 piano tuners

Estimation

Estimate the number of times, N, a heart beats in a lifetime.

Solution:

• An average lifetime \( t \approx 70 \text{ yrs} \)

• Average # of heartbeats per minute: \( \approx 60 \)

• 1 year = \( 365 \times 24 \times 60 = 525 \times 600 \min \approx 5 \times 10^5 \min \)

\[ \Rightarrow N \approx 60 \times (5 \times 10^5) \times 70 \approx 2,000,000,000 \]

\[ \Rightarrow \text{Average heart during an average lifetime beats about 2 billion times.} \]
For Next Time:

• Check out class website, read syllabus
• Read Chapter 1
• Start on the homework for Chapter 1
• Study for Quiz 1 (Ch. 1, 2) on April 12th