Physics 111

Lecture 02

Thursday, August 26, 2004

• End of Intro
• Chapter 1: dimensional analysis, scaling, word problems, coordinates
• Chapter 3: vectors: adding, subtracting
Lab write-up will be provided for this week’s lab when you get to lab in NSC 136.
From our pre-semester surveys, we find...

<table>
<thead>
<tr>
<th>Course</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>51%</td>
</tr>
<tr>
<td>Female</td>
<td>49%</td>
</tr>
<tr>
<td>College Physics</td>
<td>6%</td>
</tr>
<tr>
<td>High School Physics</td>
<td>80%</td>
</tr>
<tr>
<td>AP</td>
<td>2%</td>
</tr>
<tr>
<td>College Calculus</td>
<td>51%</td>
</tr>
<tr>
<td>High School Calculus</td>
<td>60%</td>
</tr>
</tbody>
</table>
What do you hope to get out of this course?

The misconceptions:

• “A good grade”
• “In depth knowledge of physics as a whole with knowledge of all topics.”
What do you hope to get out of this course?

Frequent or interesting responses:
- “Preparation for the MCAT.”
- “...to be challenged.”

Another benefit that *I* hope you derive:
- Stimulated curiosity
What do you expect from the lectures?

The misconceptions:

• “A clear explanation of what I have read in the textbook.”
• “What I need to do the homework.”
• “To go over material and problems done.”
• “To gain complete understanding of the material.”
• “…detailed explanations of the problems.”
What do you expect from the lectures?

Interesting responses:
• “Hopefully explosions.”

Closer to the mark:
• “To gain an understanding of [what I’m] learning outside of class…with…different learning techniques.”
• “Helpful insight to make learning Physics easy.”
What do you expect from the book?

The misconceptions:

• “…to fully understand the section read on the night before the lecture.”
• “…in depth explanation of all physics.”

Selected responses:

• “Words.”
• “Hours of torment”
What do you expect from the book?

Closer to the mark:

• “To prepare me for lecture.”
• “Details about specific problems.”
• “To give good examples on how to do problems.”
• “Reference source.”
• “Examples not discussed in class.”
Chapter 1

Dimensions and Scale

**Dimensional Analysis** or, why it’s a good idea to carry units around with you?

**Scaling Arguments** - thinking through problems without doing complicated math!
What is the formula for the magnitude of the velocity of an object (a.k.a. its speed)?

Hmmm…Well, in America, we typically talk about the speed of a car…That’s given in miles per hour.

\[ v = \text{miles/hr} \]

So, what’s measured in miles? Distances!

And, what’s measured in hours? Times!
We have now “empirically” determined a formula for speed!

\[ |v| = \frac{d}{t} \]

We will take advantage of dimensional analysis frequently during this course!

Take the time to learn and know your units!
Things you should know...

**Trigonometry:** sines, cosines, tangents, etc.

**Geometry:** areas, volumes, angles, etc.

**Algebra:** solving for unknowns, graphing, etc.
Okay, here’s an easy problem:

What are the perimeter and area of this plane figure?

\[ P = 2w + 2d \]
\[ A = w \cdot d \]
What are the perimeter and area of this plane figure?

Worksheet Problem #1

\[ P = 2w + 2d \]

\[ A = wd \]
How do we find the perimeter of this plane figure?

I got 3.25”

Let’s lay a string around the perimeter. Next, straighten it out and measure the length of the piece of string that just completely encompasses the perimeter of this plane figure.
How do we find the area of this plane figure?

I got 0.73 sq. in.

Remember?

Divide the figure into boxes and then count them up!
Physics requires you to apply all the knowledge you’ve gained in your life thus far to new and often difficult problems.

Physics is NOT about memorization!!!

Physics is about **Thinking**!
Scaling Arguments:

What happens to the perimeter of a square if we double the length of its sides?

perimeter ∝ length
What happens to the area of a square if we double the length of one of its sides?

\[ \text{area} \propto \text{length}^2 \]
What happens to the perimeter of a shape if we double its scale?
Predictions!

Worksheet Problem #2

It’s time to act like scientists!

Commit your predictions in writing to the worksheet. IMPORTANT--explain your reasoning!

Okay, now talk with your neighbor. Relate your reasoning!

New predictions?
What happens to the perimeter of a sdfjlkj3 if we double its scale?

Scaling Arguments:

perimeter $\propto$ length

It Still Doubles!
What happens to the area of a sdfjlkj3 if we double its scale?

Worksheet Problem #2
Continued…

It increases by 4X!

Area $\propto \text{length}^2$
Ch 1: Dimensions & Scale

Ponder This...

Ratio of Surface Areas?

3 X Larger Statue of King Henry VII

Ratio of Volumes?

Actual Size King Henry VII

Phys 111

Thurs Aug 26
How many pairs of shoes are purchased each year in the United States?

1) 50,000
2) 500,000
3) 5,000,000
4) 50,000,000
5) 500,000,000
6) 5,000,000,000
7) 50,000,000,000
8) 500,000,000,000

Worksheet Problem #3
“shoes”
Worksheet Problem #4

“words”

Write a mathematical expression for the following statement:

“There are six times as many students as professors at this university.”
FYI: Error Rates

- College Calculus-Level Students: 37%
- College Algebra-Level Students: 57%
- University Physical Science Faculty*: 12%
- University Social Science Faculty*: 55%
- High School Physical Science Faculty*: 26%
- High School Social Science Faculty*: 67%

* for a similar test

Data from Lochhead (1981)
We must use vectors to describe many physical quantities in 2D or 3D. Being able to decompose, add and subtract vectors is an essential skill in physics.
The keys are 9 cm from the left edge of the desk.
Locating Stationary Objects

Coordinate System

\[ x = -37 \text{ cm} \]

Position

"The keys are 37 cm from the right edge of the desk."
Our example involving the location of keys on the top of a desk was simple in that we only located the keys in 1-dimension.

What changes when we have to specify the position using two coordinates (in 2-D)?

We need to use 2 “coordinates”
The puck is 5 m from the center of the rink.

How do we know this?

Using Vector Addition!!

To more easily add vectors, we are free to translate them so long as we don’t change their angles or magnitudes.
Add the vector \((4 \text{ m}, 0)\) to \((0, -3 \text{ m})\)

The resultant points from the origin to the location \((+4 \text{ m}, -3 \text{ m})\) and has length \(5 \text{ m}\).
To properly specify a vector, you need to specify both its magnitude (i.e., length) and its direction.

It is often convenient to specify the direction by using an angular measurement between the vector and the $x$-axis.

$$\sin \theta = \frac{-3}{5}$$

$$\theta = -36.9^\circ$$
Which of the following represents $\vec{A} + \vec{B}$?
Worksheet Problem #5

Which of the following represents $\vec{A} + \vec{B}$?
Ch 3: Vectors

Commutative Law

\[ \vec{A} + \vec{B} = \vec{B} + \vec{A} \]
Worksheet Problem #6

Which of the following represents $\vec{A} - \vec{B}$?

1. 2. 3. 4. 5. 6.
Worksheet Problem #6

solution

Which of the following represents $\mathbf{A} - \mathbf{B}$?
Add the negative of $\mathbf{B}$ to $\mathbf{A}$.
So, here we have the vector analog to the "additive inverse."

What happens when we add this vector:

\[ \vec{A} + \vec{B} = \vec{0} \]

The negative
to this vector