Welcome!

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Course Administrator: Prof. Roy Montalvo

www.physics.rutgers.edu/ugrad/123
Syllabus and course policies at 
www.physics.rutgers.edu/ugrad/123

You need:

- iclicker (used is OK)
- register your iclicker on iclicker website (not SAKAI)
- textbook (used, previous editions OK)
- MasteringPhysics access code for homework
- calculator

<table>
<thead>
<tr>
<th>Course Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Midterm</td>
<td>15%</td>
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<tr>
<td>Second Midterm</td>
<td>15%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>30%</td>
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<tr>
<td>Workshop Quiz</td>
<td>8%</td>
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<tr>
<td>Group Work</td>
<td>8%</td>
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<td>Minilabs</td>
<td>8%</td>
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<tr>
<td>Lecture Participation</td>
<td>6%</td>
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<tr>
<td>Reading Quizzes</td>
<td>4%</td>
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<tr>
<td>Homework</td>
<td>6%</td>
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<tr>
<td>Surveys</td>
<td>2%</td>
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Diagnostic Pretest and Survey

- Pretest, Posttest, and two online surveys will help us improve the course.
- They are required (2% of your grade for completing all).
- Pretest will be given in recitation next week.
- Online survey can be found [here](#). This must be completed by 9/15 to receive credit.
The Nature of Physics

- Physics consists of observing the phenomena of nature (i.e., *experimenting*)
- Establishing patterns in the observed phenomena
- Coming up with ideas and *concepts* that describe and explain the patterns and phenomena.
- The sets of ideas/concepts which help us understand the phenomena are called *physical theories*. 
Physics encompasses all natural sciences!

- Astronomy
- Chemistry
- Biology
- Geophysics
**IDEALIZED MODELS**

- Reduce problem to essentials
- May wish to ignore minor effects (to start) (e.g., friction, wind, air resist.)
- Extended body → point mass

Models don’t always work (i.e. are incomplete)

**UNITS:** “SI” System (MKS Units)

- LENGTH: meter
- MASS: kilogram (not weight!)
- TIME: second
Standards and units

- Base units are set for length, time, and mass.
- Unit prefixes size the unit to fit the situation.

(a) $10^{26}$ m
Limit of the observable universe

(b) $10^{11}$ m
Distance to the sun

(c) $10^{7}$ m
Diameter of the earth

(d) 1 m
Human dimension

(e) $10^{-5}$ m
Diameter of a red blood cell

(f) $10^{-10}$ m
Radius of an atom

(g) $10^{-14}$ m
Radius of an atomic nucleus

(orders of magnitude)
# Unit prefixes

## Table 1.1 Some Units of Length, Mass, and Time

<table>
<thead>
<tr>
<th>Length</th>
<th>Mass</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 nanometer = 1 nm = 10^{-9} m (a few times the size of the largest atom)</td>
<td>1 microgram = 1 μg = 10^{-6} g = 10^{-9} kg (mass of a very small dust particle)</td>
<td>1 nanosecond = 1 ns = 10^{-9} s (time for light to travel 0.3 m)</td>
</tr>
<tr>
<td>1 micrometer = 1 μm = 10^{-6} m (size of some bacteria and living cells)</td>
<td>1 milligram = 1 mg = 10^{-3} g = 10^{-6} kg (mass of a grain of salt)</td>
<td>1 microsecond = 1 μs = 10^{-6} s (time for space station to move 8 mm)</td>
</tr>
<tr>
<td>1 millimeter = 1 mm = 10^{-3} m (diameter of the point of a ballpoint pen)</td>
<td>1 gram = 1 g = 10^{-3} kg (mass of a paper clip)</td>
<td>1 millisecond = 1 ms = 10^{-3} s (time for sound to travel 0.35 m)</td>
</tr>
<tr>
<td>1 centimeter = 1 cm = 10^{-2} m (diameter of your little finger)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 kilometer = 1 km = 10^{3} m (a 10-minute walk)</td>
<td></td>
<td></td>
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</tbody>
</table>
CONVERSIONS

millimeter = 10^{-3} \text{ m}
nanometer = 10^{-9} \text{ m}
kilometer = 10^3 \text{ m}

 aside:

\begin{align*}
\text{Scientific notation:} & \quad 10^3 = 1,000 \\
7.5 \times 10^3 &= 7,500 \\
10^{-3} &= 0.001 \\
6.2 \times 10^{-3} &= 0.0062 \\
\text{NOT:} \quad 6.2 \times 10^{-3}
\end{align*}

British units: e.g., 1 inch = 2.54 cm

In general, a number is meaningless without units (e.g., I weigh 80)

BE CONSISTENT; USE STANDARD UNITS!

Common Concept: (Distance) = (Velocity) (Time)

\[ d = v t \]

Car moves 10 m/s for 1 minute. What distance is traveled?

\[ d = (10 \text{ m/s}) (1 \text{ min}) = 10 \text{ (m-min)/s} \]
\[ d = (10 \text{ m/s}) (1 \text{ min})(60 \text{ s/min}) = 600 \text{ m} \]

Units must be consistent in equation:

\[ d = \frac{1}{2} at^2 \quad \text{[m]} = \text{[m/s}^2]\text{[s}^2]\]
UNCERTAINTY

NO PHYSICAL MEASUREMENT IS EXACT!
(Some physical constants are defined to be exact)

ALWAYS SOME UNCERTAINTY TO MEASUREMENTS

EXAMPLE: Archery – Who is more accurate?
Who is more precise?

Paul is more accurate:
Closer representation of true value

Ringo is more precise:
Less “scatter” (precisely off target)

Represent uncertainty with: ±
My height = 2.0 ± 0.1m

→ Not shorter than 1.9m
Not taller than 2.1m

Also called “error bar” or “error”
Alternatively, use % error

My height is 2.0 m ± 5%

NOTE: Same % error can be different absolute error!

College Ave Campus is 2.0 km ± 5% from PLH

→ ±100 m

SIGNIFICANT FIGURES

0.005 : 1 S.F.
5.000 : 4 S.F. (Mastering Physics: most problems have 3 S.F.)
5.0005 : 5 S.F.
5000: AMBIGUOUS

WRITE: My height = 1.85 m → ± 0.01 m

ADD, SUBTRACT:

1.85 m + 1.0000 m = 2.85 m!
1.85 m – 1.0000 m = 0.85 m!
MULIPLY & DIVIDE:
Area of screen: \(3.45 \text{ m} \times 2.95 \text{ m} = 10.1775 \text{ m}^2\)
\[= 10.2 \text{ m}^2\]

Suppose know lengths to 1 cm:
\[\left(3.45 \pm 0.01 \text{ m}\right) \left(2.95 \pm 0.01 \text{ m}\right)\]
\[= 10.2 \pm 0.03 \pm 0.03 \pm 0.001 = 10.2 \pm 0.1 \text{ m}^2\]

ESTIMATES, ORDERS OF MAGNITUDE
IMPORTANT ASPECT OF PHYSICS (AND LIFE)!

Q: How many students in Lecture Hall?

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>30</td>
<td>300</td>
<td>3,000</td>
<td>30,000</td>
</tr>
</tbody>
</table>

DON’T BE AFRAID TO MAKE **REASONABLE** GUESS

Q: How much cash in Lecture Hall?

<table>
<thead>
<tr>
<th></th>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$10</td>
<td>$100</td>
<td>$1000</td>
<td>$10,000</td>
<td>$100,000</td>
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</tbody>
</table>

Phet estimation game
CLICKER PROBLEM

- Beans occupy 900 ml (900 cm³) in beaker.

- Take one bean to measure after class.

- Estimate the number of beans in the beaker.

- Next lecture: Hand in estimate – win prize!
SCALARS & VECTORS

Some physical quantities fully characterized by a number:

my height = 1.7 m
my mass = 65 kg
my IQ = 300

These are **scalar quantities** (scalars)

Other quantities require **magnitude** and **direction** to be fully characterized: Vectors

Wind: 6 km/h NE
Ocean Current: 10 m/s W
Displacement: Commute 16 km NNE

Draw vectors as arrows:
STRAIGHT LINE MOTION

(A) R.U. bus moves along College Ave

At time \( t_1 \) it is at Mine Street
At a later time, \( t_2 \), it is at Hamilton Street

WHAT IS THE DISPLACEMENT OF THE BUS?

![Diagram showing bus movement from Mine Street to Hamilton Street and back to Mine Street.]

\[
\text{displacement} = x_2 - x_1 = 250 \text{ m}
\]

(B) Now the bus returns from Hamilton Street to Mine Street

\[
\text{displacement} = x_2 - x_1 = 250 \text{ m}
\]

What is the distance traveled?

\[
250 \text{ m} + 250 \text{ m} = 500 \text{ m}
\]

What is the net displacement?

\[
250 \text{ m} + (-250 \text{ m}) = 0 \text{ m}
\]
• What was the velocity of the bus in part (A)?

Average x-velocity: \( v_{av_x} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t} \)

Suppose trip took 10 seconds:

\[ \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} = 250 \text{ m} / 10 \text{ s} = 25 \text{ m/s} \]

Is this the \( x \)-velocity of the bus?

NO! It is the average \( x \)-velocity!

• What is the average \( x \)-velocity in part (B)?

\[ \frac{(x_2 - x_1)}{(t_2 - t_1)} = \frac{-250 \text{ m}}{10 \text{ s}} = -25 \text{ m/s} \]
Suppose the speed of the bus increases as moves from Mine Street to Hamilton Street.

Use $x$-$t$ plot:

$$v_{av_x} = \frac{x_2 - x_1}{t_2 - t_1}$$

$v_{av_x}$ is the slope of the line connecting $M$ + $H$ in $x$-$t$ plot.

**Instantaneous Velocity:**

$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

So in $x$-$t$ plot have:

$$x = x(t) \rightarrow v_x = \frac{dx}{dt}$$
Finding velocity on an $x$-$t$ graph

- At any point on an $x$-$t$ graph, the instantaneous $x$-velocity is equal to the slope of the tangent to the curve at that point.

As the average $x$-velocity $v_{av-x}$ is calculated over shorter and shorter time intervals ...

... its value $v_{av-x} = \Delta x/\Delta t$ approaches the instantaneous $x$-velocity.

The instantaneous $x$-velocity $v_x$ at any given point equals the slope of the tangent to the $x$-$t$ curve at that point.
Moving Man Simulation