Section 1 – An Introduction to Physics 204A

Section Outline

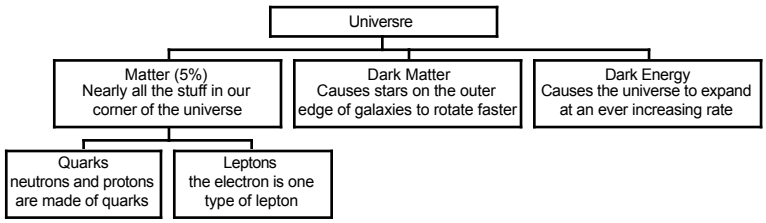
1. A Preview of Physics
2. A Preview of Phys 204A
3. The Scientific Method
    a. Observation
    b. Theory
    c. Prediction
    d. Experiment
4. Coordinate Systems

1. A Preview of Physics

Physics tries to answer the same question every human has asked since the dawn of mankind: Why are we here?

Physicists break this question down into two parts:

- What is the universe made of? Here is what we know:



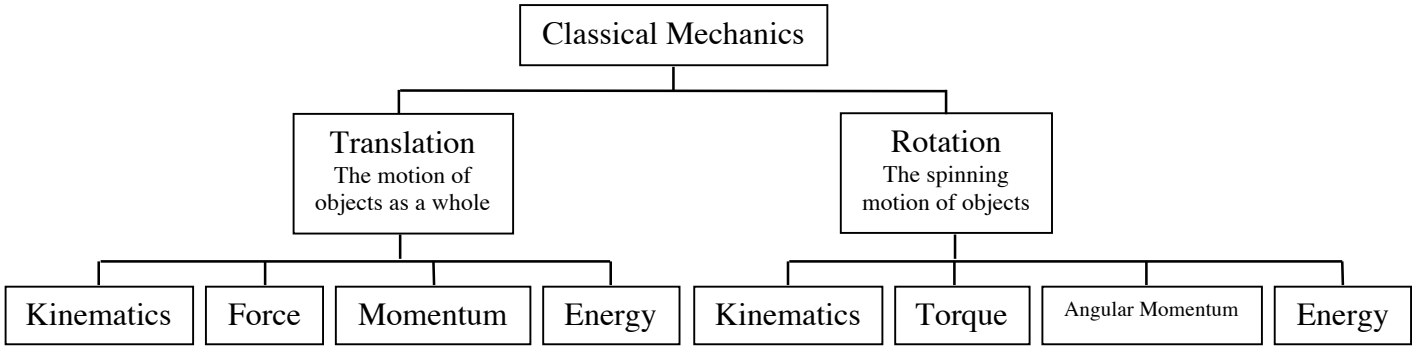
- How do the parts interact?
    This is the topic we'll begin to investigate in this class.

The Four Fundamental Interactions

Interaction	Strength	Example
Gravitational	1	Solar System
Electromagnetic	10^{36}	Hydrogen Atom
Weak Nuclear	10^{25}	Beta Decay
Strong Nuclear	10^{38}	Nuclear Stability

2. A Preview of Physics 204A

How do the parts interact? A better way to ask the question is: What do objects do and why do they do it? These are the central questions of the study of Classical Mechanics.



Kinematics describes what objects do. That is to say, kinematics describes motion.
Interactions explain why objects do what they do. Interactions are described in terms of forces, torques, energy, momentum and angular momentum.

During our study this semester, we will discover seven and only seven fundamental laws of physics:

Newton's Laws of Motion explain the concept of force.

1. Newton's First Law - The Law of Inertia
2. Newton's Second Law - $\sum F=ma$
3. Newton's Third Law - The Law of Action/Reaction

Conservation Laws

4. Conservation of Energy
5. Conservation of Linear Momentum
6. Conservation of Angular Momentum

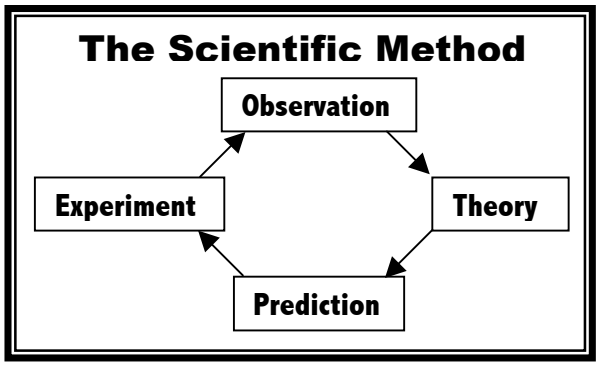
One of the Four Interactions

7. The Law of Universal Gravitation $F_g = G\frac{m_1 m_2}{r^2}$

3. The Scientific Method

The standard way in which scientists discover the answers to questions is called "The Scientific Method."

Observations are collected to and synthesized to produce a theory that explains the results of all previous observation. However, a theory is useless unless it can predict the results of new experiments. The observations of the results of the new experiments are used to test the validity of the theory. If the results are consistent with the predictions, then the theory is accepted for further testing. If the results contradict the theory it must be modified or abandoned. Notice that this means that science can only disprove theories and never prove theories correct. The theories we accept are ones that have yet to be proven wrong.



3a. Observation (Measurement)

Make measurements as carefully as possible, in standard units, with proper attention to significant figures.

International System of Units (SI)
- mass in kilograms (kg)
- time in seconds (s)
- length in meters (m)

Use the metric prefixes for powers of ten (memorize these!)

prefix	name	power
μ	micro	10^{-6}
m	milli	10^{-3}
c	centi	10^{-2}
k	kilo	10^{3}
M	mega	10^{6}
G	giga	10^{9}

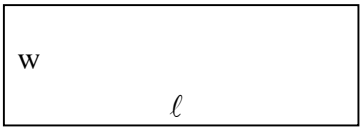
Example 1.1: Convert 100 miles to kilometers.
Use the "multiply by one" method. $(100\,\text{mi})\left(\frac{5280\text{ft}}{\text{mi}}\right)\left(\frac{12\,\text{in}}{\text{ft}}\right)\left(\frac{2.54\,\text{cm}}{\text{in}}\right)\left(\frac{1\,\text{m}}{100\,\text{cm}}\right)\left(\frac{\text{km}}{1000\text{m}}\right) = \underline{\underline{161\text{km}}}$.

COMMENT ON PROBLEM SOLVING:
A problem solution is not just some equations and some numbers. The reasoning behind the solution is the most important aspect. The best way to describe reasoning is with words. You will always see me write the words that explain what I am doing. I expect you to do the same thing on homework, quizzes, and exams.

Significant figures:
The proper rules for significant figures will be discussed in lab.
For homework problems use the "rules of thumb:"

1) Multiplication/Division - the answer has the same number of significant figures as the quantity with the fewest significant figures.
2) Addition/Subtraction - the answer has the same number of decimal places as the term with the fewest decimal places.

Example 1.2: Find the area and perimeter of a 75m by 12.5 m field.



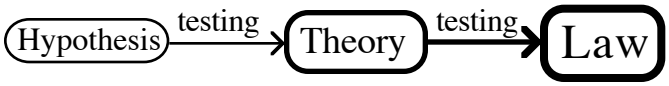
Given:	Find:
$\ell = 75\text{m}$	A = ?
w = 12.5m	p = ?

The definition of area is, $A \equiv \ell w = (75)(12.5) = 937.5$.
Using the sig. fig. rules, $\boxed{A = 940\text{m}^2}$.
The definition of perimeter is, $p \equiv 2\ell + 2w = 2(75) + 2(12.5) = 175.0$.
Using the sig. fig. rules, $\boxed{p = 175\text{m}}$.

COMMENT ON PROBLEM SOLVING:
The most effective way to solve physics problems is to begin with a sketch of the situation. Then list the known information and the quantities you for which you are searching. Again, I will always take the time to do this and I expect the same from you.

3b. Theory

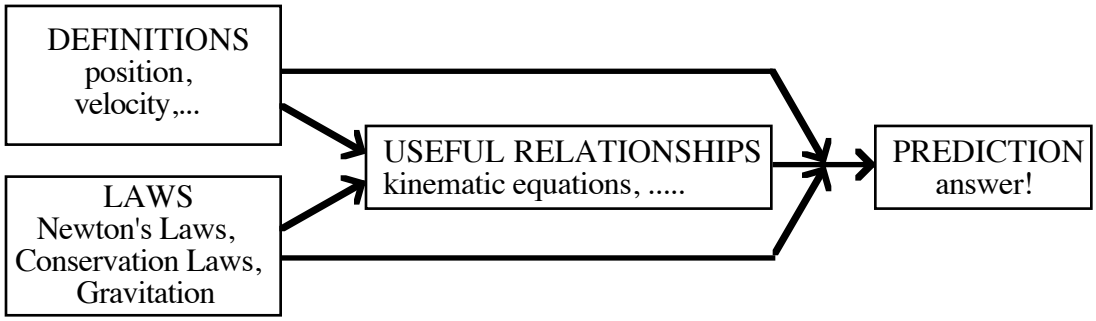
Theories must explain all previous experiments and must be predictive. An initial guess at a theory is called a "hypothesis." If the hypothesis withstands repeated tests it is called a "theory." If the theory withstands such a large number of tests that it explains a great variety of phenomena, it becomes a "law."



This nomenclature is not always followed very carefully.

3c. Prediction

This is essentially what you're asked to do in the homework problems. Definitions (which are indicated with a "≡" sign) and laws (which aren't equations at all, they are an idea that can lead to an equation – remember there are only the seven listed previously) are sometimes used to create useful relationships (which are indicated with an "=" sign). Notice that solving a homework question is not a matter of plugging numbers into a formula, but instead it is a matter of reasoning from the definitions and laws.



COMMENT ON PROBLEM SOLVING:
Since reasoning is the key to homework problems, your solutions, at a minimum, MUST use words to:

- State the names of the relevant definitions, laws, and useful relationships (these will be in the section summaries and they will be written on the last page of the exams).
- Explain the reasoning required for the key steps.

Please use 8.5" x 11" paper.

I will always follow these rules as I solve example problems in these notes and in class. As I do, please focus your attention on the reasoning and not just on "getting the answer." Be sure to ASK QUESTIONS!

3d. Experiment

Experiment is the final arbiter! You will work on experimental technique in lab.

4. Coordinate Systems (Reference Frames)

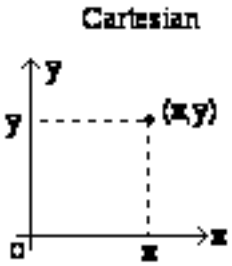
Coordinate systems are essential to give meaning to measurements. For example, if you ask, where is Kendall Hall? The answer will always refer to some starting point. Such as, it is 100meters west of the Physical Science Building.

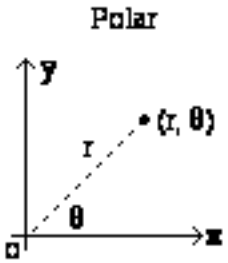
The choice of coordinates doesn't affect the natural processes being observed.

To establish a coordinate system you must choose:

- an origin.
- the type (Cartesian, polar, spherical,...).
- the direction of the axes.

Standard Coordinate Systems in 2D



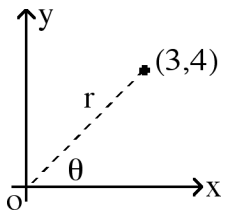


$x = r\cos\theta$ $\qquad$ $r = \sqrt{x^2 + y^2}$ (Pythagorean Theorem)

$y = r\sin\theta$ $\qquad$ $\theta = \arctan\frac{y}{x}$ (Definition of Tangent)

Example 1.3: Find the polar coordinates for the point (3.00m, 4.00m).

Given:	Find:
x = 3.00m	r = ?
y = 4.00m	θ = ?



Using the Pythagorean theorem,

$r = \sqrt{x^2 + y^2} = \sqrt{3^2 + 4^2} \Rightarrow \boxed{r = 5.00\,\text{m}}$.

Using the definition of the tangent, $\theta = \arctan\frac{4}{3} \Rightarrow \boxed{\theta = 53.1^\circ}$.

Section 1 - Summary

We previewed the science of physics and pointed out that physics tries to answer two questions:

- What is the universe made of?
- How do the parts interact?

This class will predominantly be about the later. Physics is a study that is really about reasoning as opposed to plugging numbers into equations. So it is important to focus on laws and ideas not formulas.

The Scientific Method is the central paradigm that leads us to accept the laws of physics.

You need to be able to effectively use metric prefixes, convert units, and maintain proper significant figures.

We began to see the importance of coordinate systems and remembered how to convert from polar to rectangular and back.