General Physics 1

Class Goals

- <u>**Develop/improve problem solving skills**</u>

  https://youtu.be/FEl0H2ETYrw

- Learn the basic concepts of mechanics and learn how to apply these concepts to solve problems.
- Build on your understanding of how the world works.
- Learn how to take advantage of the laws of physics.

Topics

- Kinematics
  - 1 and 2 dimensional motion
  - Linear motion
  - Rotational motion
- Forces
- Mechanical Energy
- Momentum
- Basic Fluid Mechanics
- Basic Thermal Physics and Thermodynamics

Starting Chapter 1
Units

SI Base units (metric)

- Length - meter (m)
- Mass - kilogram (kg)
- Time - second (s)

- Temperature - kelvin (K)
- Amount of substance - mole

- Electric current - Amps (A) - use in Physics 2
- Luminous intensity – candela (cd)

Compound Units

Other Units can be derived by combining the base units.

- Force - Newton (N)

  $N = kg\ m/s^2$

- Pressure - Pascal (Pa)

  $Pa = N/m^2 = kg/(m\ s^2)$

Rules for Units

When multiplying and/or dividing, you can have different units.

The result will be a value that has units corresponding to a product/quotient of the original units.

Example 1.	10 meter/5 seconds	= 2 meters/second	
	10 m / 5 s	= 2 m/s	
Example 2.	20 Joules / 5 seconds	= 4 Joules/seconds	= 4 Watts
	20 J / 5s	= 4 J/s	= 4 W
Example 3.	5 Newtons x 2 meters	= 10 Newton meters	= 10 Joules
	5 N x 2 m	= 10 N m	= 10 J

Example4. 8 kilograms x 1 meter/(4 seconds^2) = 2 kilograms meters/seconds^2 = 2 Newtons

8 kg (1 m / 4 s^2) = 2 kg m/s^2

Newton: N = kg m/s^2

Rules for Units.

This is the first of two simple but ***extremely*** important rules that will be used throughout any physics class.

When you are adding/subtracting quantities, the quantities need to have the same units!!!!

You can't add/subtract values that have different units. The answer is meaningless.

Example: 5 meters + 10 meters/second makes no physical sense.

5 m + 10 m/s

One value is a length, the other is a velocity.

You can't add a length to a velocity.

However if we multiply the velocity by a time, we can now have:

5 m + (10 m/s)(2 s) = 25 m

Now both values are lengths and we can add them together.

Why is this important

1)

You need to make sure your calculations make physical sense.

If you put together an equation, and you are adding/subtracting values with different units, that is an immediate sign that you are making a mistake.

2)

You can use the units to see how certain values need to be combined to get to the desired value.

Example: If you want a velocity, you need to divide a distance by a time.

Quite often, you can use this rule to determine what type of equation, or which formula, is required to be used.

Dimensional Analysis

Velocity has units of:	length/time
In SI units:	m/s
Acceleration has units of:	$length/time^2$
Same as:	velocity/time
Acceleration has units:	m/s^2

- Checking the units of your answer is a good way of checking your work for any mistakes.

Converting units

Suppose you want to convert miles per hour to meters per second.

Need to change miles to meters AND hours to seconds.

$$\frac{miles}{hour} x \frac{1hour}{3600\ seconds} x \frac{1609\ meters}{1\ mile} = \frac{\#\ meters}{second}$$

Example: A car is traveling 60 miles per hour. How fast is the car going in meters per second?

$$\frac{60\ miles}{hour} x \frac{1hour}{3600\ seconds} x \frac{1609\ meters}{1\ mile} = \frac{27\ meters}{second}$$

Convert a measurement in feet to meters

- A basketball hoop is 10 feet above the ground. How high is it in meters?

Helpful estimate is (~ 3ft/m)

- What I know: 12 inches in a foot
  2.54 centimeters in an inch
  100 centimeters in a meter

$$10\ ft\ x\ \frac{12\ in}{1\ ft} x \frac{2.54\ cm}{1\ in} x \frac{1m}{100\ cm} = 3.048\ m$$

So 10 feet is just a little more than 3 meters.

Uncertainty and Significant digits

- Uncertainty deals with the accuracy of a measurement.

- When you take a measurement, the number of digits that you know accurately are significant.

- If you were to use a meter stick to measure the length of a book, you could see the number of centimeters and hopefully the number of millimeters. Since the meter stick doesn’t have any smaller markings, you can’t be any more accurate.

- If you want more significant digits, you need a more accurate device.

Counting Significant digits

Any number that is not a zero is significant.
Zeroes at the end **and after the decimal** are significant.
Zeroes in between non-zeroes are also significant.
Zeroes in between significant digits are significant.

Examples:

2632 has 4 s.d.
1420000 has 3 s.d.
1420000.00 has 9 s.d.
0.0000002 has 1 s.d.
5.0000002 has 8 s.d.
407 has 3 s.d.

Math involving significant digits

Multiplying or dividing numbers. Count to see how many s.d. each number has. Your answer should have the same amount as the number with the least amount of s.d.

example: 74.2 *2.2 = 163.24

2 s.d. = 160

Adding and subtracting numbers

Answer should as accurate as your least accurate number.

Example:12.2 + 2.345436434625

12.2xxxxxxxxxxxxx

+ 2.345436434625

14.5

Dealing with really big or small numbers

- Really big or small numbers can get annoying to work with.
- Make use of scientific notation

examples: 299 792 458 m/s

rewrite as 3.0×10^8 m/s

0.00000065 m

rewrite as 6.5×10^{-7} m

See tables 1.1-1.3 for more examples.

Metric Prefixes

Prefix:	Symbol:	Magnitude:	Meaning (multiply by):
Yotta-	Y	10^{24}	1 000 000 000 000 000 000 000 000
Zetta-	Z	10^{21}	1 000 000 000 000 000 000 000
Exa-	E	10^{18}	1 000 000 000 000 000 000
Peta-	P	10^{15}	1 000 000 000 000 000
Tera-	T	10^{12}	1 000 000 000 000
Giga-	G	10^{9}	1 000 000 000
Mega-	M	10^{6}	1 000 000
myria-	my	10^{4}	10 000 (this is now obsolete)
kilo-	k	10^{3}	1000
hecto-	h	10^{2}	100
deka-	da	10	10
-	-	-	-
deci-	d	10^{-1}	0.1
centi-	c	10^{-2}	0.01
milli-	m	10^{-3}	0.001
micro-	u (mu)	10^{-6}	0.000 001
nano-	n	10^{-9}	0.000 000 001
pico-	p	10^{-12}	0.000 000 000 001
femto-	f	10^{-15}	0.000 000 000 000 001
atto-	a	10^{-18}	0.000 000 000 000 000 001
zepto-	z	10^{-21}	0.000 000 000 000 000 000 001
yocto-	y	10^{-24}	0.000 000 000 000 000 000 000 001

Metric System Prefixes

Be comfortable with these for certain.

(I expect you to know these on exams in GP1 and GP2.)

kilo-	k	10^3	1 000
centi-	c	10^{-2}	0.01
milli-	m	10^{-3}	0.001
micro-	μ	10^{-6}	0.000 001
nano-	n	10^{-9}	0.000 000 001

Estimations and order of magnitude calculations

Very useful when an exact number is not necessary.

The order of magnitude is the power of 10 found when writing a number in scientific notation.

Speed of light is 299 792 458 m/s or 3×10^8m/s

You can say that the speed of light is on the order of 10^8m/s.

Acceleration due to gravity: 9.8 m/s^2
Estimate it as: 10 m/s^2

Estimations and order of magnitude calculations

- Make rough calculation easier.
- Handy when you don’t have your calculator.

Example: Find the area of a circle with a radius of 2 meters.

Area = π*(radius)^2

Estimated solution, with π approximately 3

Area = 3*(2 m)^2= 12 m^2

If you typed in 3.14159 for π, your answer would be about 12.6 m^2

Estimations and order of magnitude calculations

Estimate the number of people needed to make ‘human chain’ across Tennessee.

Estimations and order of magnitude calculations

Estimate the number of people needed to make ‘human chain’ across Tennessee.

TN is about 500 miles long

1 mile is about 1.6 km.

So TN is about 800 km long.

Ballpark reach of a person is about 1 meter.

800km is 800*1000 meters = 800 000 meters.

You would need about 800 000 people.

Coordinate Systems

We will mostly use Cartesian coordinates. (x, y)

You can pick whatever point you want to be the origin or reference point. Pick one that is convenient.

There is also the polar coordinate system, but we won't use it much.

(r, θ) The r is for a magnitude, and θ is the angle from a reference axis.

Trigonometry

We will be using trig in General Physics.

Important when dealing with vectors.

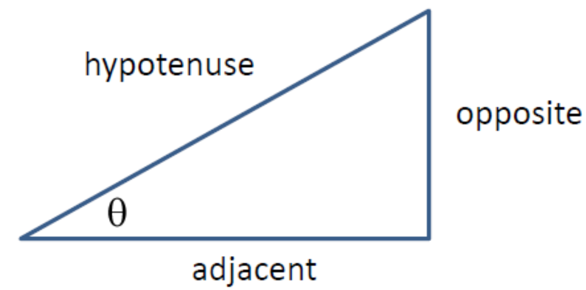
(will cover vectors soon)

<u>You need to know how to use trig functions</u>.

sine, cosine, tangent…

Some basic trig

$\sin \theta$ = opp/hyp



$\cos \theta$ = adj/hyp

$\tan \theta$ = opp/adj

$\sin^{-1}$ (opp/hyp) = θ

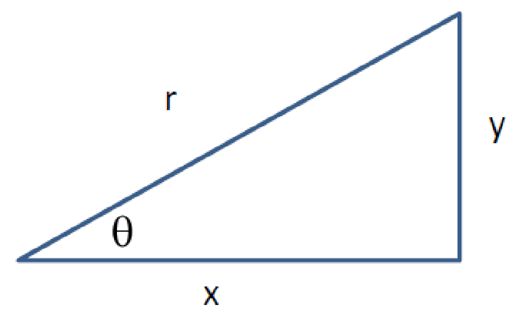
$\cos^{-1}$(adj/hyp) = θ

$\tan^{-1}$(opp/adj) = θ also tan = sin/cos

Some trig values for angles in degrees

Angle	sin	cos	tan
0	0	1	0
30	½	$\sqrt{3}/2$	$1/\sqrt{3}$
45	$\sqrt{2}/2$	$\sqrt{2}/2$	1
60	$\sqrt{3}/2$	½	$\sqrt{3}$
90	1	0	undefined

More trig…

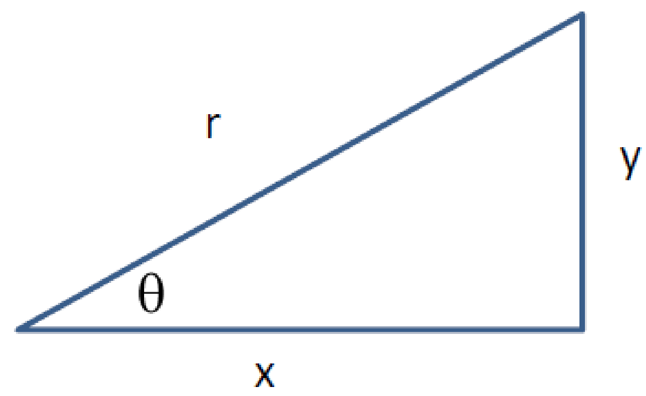


Using definitions of sin and cos we get:

$r*\cos\theta = x$

$r*\sin\theta = y$

Pythagorean theorem



Good for right triangles

$r^2 = x^2 + y^2$

$r^2 = (r*\cos\theta)^2 + (r*\sin\theta)^2 = r^2(\cos^2\theta + \sin^2\theta)$

$= r^2(\quad 1 \quad)$

Taking square root of both sides shows r = r

Trig identities can be found in the text’s appendix.

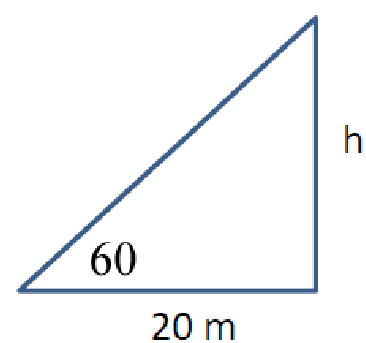
Measuring a building's height

Using trig to measure how tall a building is:

Suppose you walk 20 meters from the base of a building and then you shine a laser pointer to the top of the building's wall. The laser beam makes an angle of 60 degrees with the ground. Using trig you can find how high the building is.

Use tan 60 = (h/20 m)

h = 20 tan 60 = 35 m



Types of physical quantities

- 2 Types of quantities

 - scalars

  magnitude

   (mass, speed, time, energy)

 - vectors

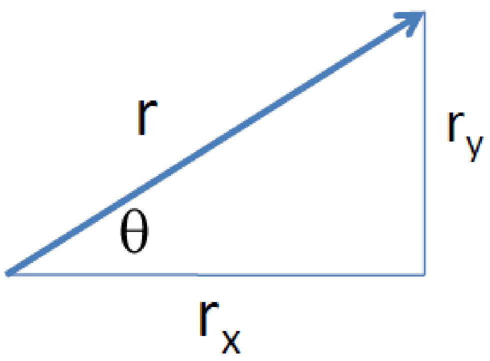
  magnitude and direction

   (velocity, acceleration, force)

Vectors

Components

The components of a vector can be found using trig.



$r*\cos\theta = r_x$

$r*\sin\theta = r_y$

Vector Addition

When adding vectors, you add the like components.

Vector A has component A_x= 2 and A_y= 4

Vector B has components B_x= 5 and B_y = 6

What is C, if A + B = C

The resultant vector (C) has components:

C_x= 2+5 = 7

C_y= 4+6 = 10

Vector Addition

Graphically adding vectors A (2,4) and B (5,6)