Advanced Physics Summer Packet

The science of physics was developed to help explain the physics environment around us. Many of the subjects covered in this class will help you understand the physical world around you. The topics to be covered are:

1D & 2D Motion	Temperature & Heat
Forces and Motion	Thermodynamics
Circular Motion	Waves & Sound & Light
Work & Energy	Electrostatics
Impulse & Momentum	Current Electricity
Rotational Torque	Magnetism & Induction
Simple Harmonic Motion & Springs	Optics
Fluids	Atomic & Nuclear Physics

Because there is a lot of material to cover, this class will be fast-paced and rigorous. Be prepared to work long hours and do independent study. You must be committed to this class in order to do well.

The purpose of this packet is for all students to have a firm foundation on the mathematical concepts used in Advanced Physics. You should be comfortable with the following materials since they will be used throughout the year, and this information will not be covered in the school year.

Please be sure to understand the math concepts and do all assignments before the beginning of the school year. **The packet will be due the first day of class and there will be a quiz on the math concepts the first week.**

ASSIGNMENT:

Math Review Worksheets (Sig Fig & Units Worksheet, Dimensional Analysis Worksheet, and Math Review & Vectors Worksheet): For all the worksheets, please show ALL work for your computations and have units for all your final answers (if applicable).

If you have any questions, feel free to email me: christine.knabe@wwisd.com

If you're ready, let's get started.

Advanced Physics

Scientific Notation

In science, very large and very small decimal numbers are conveniently expressed in terms of powers of ten. Numbers expressed with the aid of powers of ten are said to be in scientific notation.

Examples: Earth's radius = 6,380,000 m = 6.38×10^{6} m
Bohr radius of H atom = 0.0000000000529 m = 5.29×10^{-11} m

All scientific notations are composed of an integer ($0 < m \leq 1$) and powers of ten.

On the calculator: you can punch in scientific notation on a scientific calculator using the following buttons, depending on your calculator:

$\boxed{\text{EE}}$ or $\boxed{\text{Exp}}$

Example: 6.38×10^{6} m : 6.38 $\boxed{\text{EE}}$ 6 = 6.38E6 (the scientific notation on the calculator)

NOTE: Do not punch 6.38 $\boxed{\text{X}}$ 10 $\boxed{\text{EE}}$ 6, or your notation will be incorrect.

Significant Figures (Sig Figs)

The number of significant figures in a number is the number of digits whose value are known with certainty.

Example: a person's height: 1.78 m, with the measurement error being in the third decimal place.
All three digits are known with certainty, so the number contains 3 sig figs.

Rules used in determining significant figures:

1. All non-zero numbers are significant. (Ex: 1, 2, etc)
2. All zeros between 2 non-zero numbers are significant. (Ex: 4004, these 2 zeros count as sig figs)
3. All final zeros after the decimal point are significant. (Ex: 4.000, these zeros count)
4. Zeros that act as placeholders are not significant. (Ex: 0.0004 or 400, these don't count)
   Exception: 400. When a decimal point follows placeholders, they no longer act as placeholders, but now are definite sig figs. So "400." has 3 sig figs.

Math and sig figs

1. When adding/subtracting: round answer to the least number of decimal places
   Example: 24.25 m + 3.5 m = 27.75 m = 27.8 m

   Has 2 decimal places | Has 1 decimal place

2. When multiplying/dividing: round answer to the least number of total sig figs
   Example: 36.5 ÷ 3.414 = 10.69127… = 10.7

   Has 3 sig figs | Has 4 sig figs

**Never write the entire number from the calculator as your answer. Always round answers to the correct sig figs.

AP Physics

Units

In science, all numbers involve units, because all numbers are measurements of a quantity. Numbers without units mean nothing in physics, unless they are referring to a ratio.

In this class, we emphasize the system of units known as SI units. By agreement of the scientific world, a set of units are used as the standard. CGS, another system of units, may also be used:

	SI	CGS
Length	Meter (m)	Centimeter (cm)
Mass	Kilogram (kg)	Gram (g)
Time	Second (s)	Second (s)

The units for length, mass, and time, along with a few other units that will arise later, are regarded as base SI units. The word "base" refers to the fact that these units are used along with various laws to define additional units for other quantities. The units for these other quantities are referred to derived units, since they are a combination of the base units. We will discuss more about the derived units as they come up.

Unit Prefixes: you need to memorize these:

Prefix	symbol	Factor
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Other conversion factors you should know:

1 h = 3600 s

1 yr = 365.24 days

1 in = 2.54 cm

1 kg = 2.205 lb

1 m = 3.281 ft

1 m^3 = 1000 L

1 mile = 5280 ft = 1.609 km

This prefixes can be used with any base unit.
Example: 0.01 m = 1 cm -or- 1 m = 100 cm

Unit Conversion

Many quantities can be measured in several different units. Therefore, it is important to know how to convert from one unit to another.

**Note: Only quantities with the same units can be added or subtracted. If not the same unit, convert them to the same units before doing the math.
When multiplying and dividing, units can be treated as algebraic quantities.

Example: Express 979.0 m in kilometers and in feet.

$$979.0 \text{ m} \times \frac{1 \text{ km}}{10^3 \text{ m}} = 0.9790 \text{ km}$$

$$979.0 \text{ m} \times \frac{3.281 \text{ ft}}{1 \text{ m}} = 3212 \text{ ft}$$

AP Physics

Dimensional Analysis

The term dimension is used to refer to the physical nature of a quantity and the type of unit used to specify it. Distance has the dimension of length, which is symbolized as [L], while speed has the dimensions of length divided by time, or [L]/[T]. Many physical quantities can be expressed in terms of a combination of fundamental dimensions such as length [L], time [T], and mass [M].

Dimensional analysis is used to check mathematical relations for the consistency of their dimensions. Example: Is $x = (1/2)vt^2$ correct or is $x = (1/2)vt$ correct? Use dimensional analysis to verify.

$$x = (1/2)vt^2 \qquad\qquad x = (1/2)vt$$

$$[L] = \frac{L}{T}[T]^2 = [L][T] \qquad\qquad [L] = \frac{L}{T}[T] = [L]$$

Dimensions cancel just like algebraic quantities, and pure numerical factors like 1/2 have no dimensions, so they can be ignored. The dimension on the right match, so this relation is dimensionally correct.

Dimensional analysis can be used to derive equations by combining two or more equations together.

Math Review

Solving equations

It is often necessary to solve the equation so that a variable whose value is unknown is expressed in terms of known quantities. In doing so, you will need to manipulate equations to solve for the unknown.

Example: Solve for t in the following equation: $v = v_o + at$.

$$v = v_o + at$$
$$v - v_o = at$$
$$(v - v_o)/a = t$$

Make sure you are comfortable with manipulating equations.

Trigonometry

Know the basic trig functions: sine, cosine, tangent

$\sin\theta$ = opposite/hypotenuse
$\cos\theta$ = adjacent/hypotenuse
$\tan\theta$ = opposite/adjacent

Know the Pythagorean Theorem: $c^2 = a^2 + b^2$

Vectors

Some quantities can be described with a single number (with units) giving its size or magnitude. Such quantities are called scalar quantities. Examples of scalar quantities are time, temperature, and mass.

But many quantities not only have a magnitude but also a direction. Such quantities are called vectors. An example of a vector quantity is displacement. Displacement describes how far you've traveled and in which direction you have traveled. For example, a car has traveled 2 km due east. Other vector quantities are velocity, acceleration, and force.

An arrow is used to represent a vector. 2 km due east
The length of the arrow represents the magnitude
and the which way the arrow points is the direction of the quantity.

Sign Conventions

Positive and negative signs are typically used to indicate the direction of a vector mathematically. (In Physics, positive and negative signs do NOT mean positive or negative numbers, as in a number line.)

-positive sign: to the east or north (right or up)

-negative sign: to the west or south (left or down)

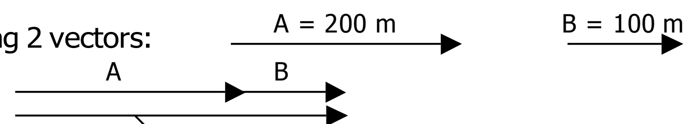
Adding Vectors

A. Head-Tail Method

-graphically adding vectors

-place the tail of the 2nd vector at the head of the 1st vector

Ex: Add the following 2 vectors:



This vector is called the resultant vector (R), which is the sum of all the vectors added together.

R = A + B

B. Adding Mathematically

1. Vectors that are in the same direction

Ex: Add together Vector A: 275 m, due east and Vector B: 125 m, due east.

R = A + B

R = +275 m + (+125 m) = +400 m

R = 400 m, due east

Ex: Add together Vector A: 275 m, due east and Vector C: 125 m, due west

R = A + C

R = +275 m + (-125 m) = +150 m

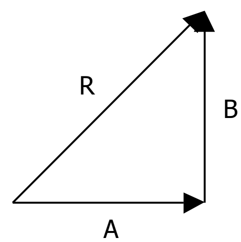
R = 150 m, due east

2. Vectors that are perpendicular to each other

-Use Pythagorean Theorem and trig

$R^2 = A^2 + B^2$

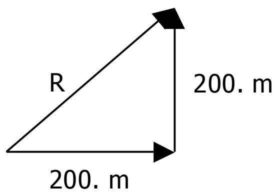
SOHCAHTOA (sine, cosine, tangent)



**Be sure your calculator is in "DEGREE" mode.

AP Physics

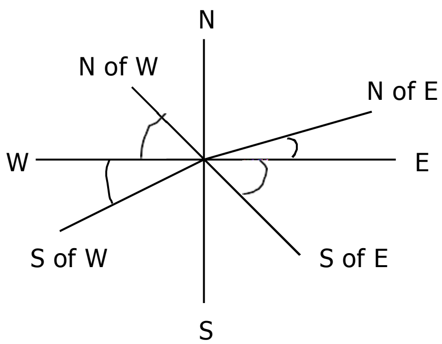
Ex: What is the magnitude and direction of R?



$R^2 = A^2 + B^2$
$R^2 = (200.\ m)^2 + (200.\ m)^2$
$R = 283\ m$

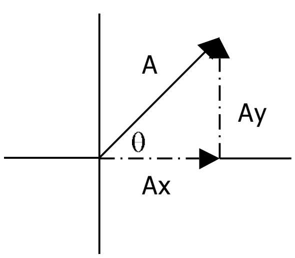
$\tan \theta$ = opp/adj = 200. m/200. m = 1
$\theta = 45°$

R = 283 m, 45° N of E



Here is the directions of a compass, if you're not familiar with them.

3. Vectors That Are Not Perpendicular to Each Other
-All vectors have an x-component and a y-component.
Whenever adding vectors that are not going in the same direction or not perpendicular to each other, you must determine the x-component and y-component of each vector and add their components together.



x-component: vector component that's parallel to x-axis
$Ax = A\cos\theta$

y-component: vector component that's parallel to y-axis
$Ay = A\sin\theta$

Steps To Adding Non-Perpendicular Vectors:
Ex: Add the following vectors: A = 50.0 m/s, 30.0° S of E
B = 25.0 m/s, 75.0° S of W

Step 1: Resolve (breakdown) each vector into its x- and y-components.
Ax = (50.0 m/s)(cos 30.0°) = +43.3 m/s   Bx = (25.0 m/s)(cos 75.0°) = -6.47 m/s
Ay = (50.0 m/s)(sin 30.0°) = -25.0 m/s   By = (25.0 m/s)(sin 75.0°) = -24.1 m/s

Step 2: Add all the x-components. Add all the y-components.

Rx = Ax + Bx   Ry = Ay + By
Rx = +43.3 m/s + (-6.47 m/s)   Ry = -25.0 m/s + (-24.1 m/s)
Rx = +36.8 m/s   Ry = -49.1 m/s

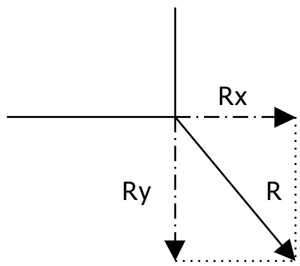
Step 3: Draw the x- and y-components of the resultant.

If the x-component is positive, draw it on the +x axis. If negative, on the −x axis.

Do the same for the y-components, except on the y-axis.

Draw the resultant vector, from the origin in a diagonal line, as shown.

As you can see, we've made a right triangle.



Step 4: Use Pythagorean Theorem to calculate the magnitude of the resultant.

$R^2 = Rx^2 + Ry^2$

$R^2 = (36.8\ m/s)^2 + (-49.1 m/s)^2$

$R = 61.4\ m/s$

Step 5: Use trig to determine the direction of the resultant. **Make sure calculator is in DEGREE mode.

Tan θ = opp/adj = Ry/Rx = 49.1/36.8

θ = 53.1º S of E

Answer: Resultant Vector = 61.4 m/s, 53.1º S of E

**Learning how to add vectors is important, because many of the quantities in Physics are vectors. And you will be using this method a lot in the first semester. So make sure you are familiar with it.

AP Physics

Name________________________

Date_________________

#

Sig Figs & Units Worksheet

1. How many significant figures are there in each of the following?

   a. 273.16 ______
   b. 186,000 ______
   c. 505 ______
   d. 1000 ______
   e. 2,000,000 ______
   f. 13.8 ______
   g. 0.00928 ______
   h. 60.080 ______
   i. 5280. ______
   j. 708.003 ______
   k. 0.0652 ______
   l. 3.040×10^{5} ______

2. In the following, convert numbers in common notation to scientific notation, or vice versa.

   a. 93,000,000 ______________________
   b. 0.000019 ______________________
   c. 606.39 ______________________
   d. 2.997×10^{10} ______________________
   e. 6.02×10^{-5} ______________________
   f. 2.5359×10^{2} ______________________

3. In the following, how many decimal places will the solution have? DO NOT SOLVE.

   a. 6.0 m + 10.73 m + 111.250 m _________
   b. 4050 L − 2.06 L _________
   c. 96.75 km + 108.43 km + 77 km _______
   d. 93.4 cm + 10.975 cm _________
   e. 0.005070 cm + 6.90 cm + 2000.860 cm _____
   f. 10.970 mL − 5.0 mL ________

4. In the following, how many digits should be in the solution to have the proper number of sig figs? DO NOT SOLVE.

   a. (797.6 m)(54 m) _______
   b. (851 cm)(24.3 cm) ________
   c. 1075 kg ÷ 15 L _______
   d. 93.4 m ÷ 10.975 m _______
   e. $(6.02 \times 10^{23}\text{ m})(12.00\text{ m})(1.660 \times 10^{-24}\text{ m})$ ________
   f. $(453.6\text{ m})(9.050 \times 10^{4}\text{ m})(239.1\text{ m})$ ________

Solve the following problems, expressing the answer in the proper number of sig figs.

5. Express the sum of 20.6 mm, 49.5 cm and 5.03 m in meters

6. If 22.5 L of gasoline is drawn from a tank originally containing 65 L of gasoline, what volume of gasoline remains in the tank?

7. What is the area of the bottom of a tank 30.0 cm long and 15.0 cm wide?

8. If the tank in Problem 7 has a volume of $2.25 \times 10^{4}\text{ cm}^{3}$, what is its height?

9. How many centimeters are there in 35.0 inches?

10. What is the distance, in kilometers, of a 2.5 mile cross-country course?

11. Convert each of the following measurements into meters.
   a. 42.3 cm
   b. 6.2 pm
   c. 21 km
   d. 0.023 mm
   e. 214 μm
   f. 570 nm

12. Rank the following mass measurements from smallest to largest:
   11.6 mg, 1021 μg, 0.0000006 kg, 0.31 mg

13. State the number of sig figs in the following measurements.
   a. 248 m _____ b. 0.00003 m _____ c. 64.01 m _____ d. 80.001 m _____

14. State the number of sig figs in the following measurements.
   a. 2.40×10^6 kg _____ b. 6×10^6 kg _____ c. 4.07×10^{16} m ______

15. Convert each of the English quantities to metric equivalents
   a. 353 ft to m
   b. 2.0 in to mm

16. Add or subtract as indicated and state the answer with the correct number of sig figs.
   a. 16.2 m + 5.008 m + 13.48 m
   b. 5.006 m + 12.00000077 m + 8.0084 m
   c. $78.05\ \text{cm}^2 - 32.046\ \text{cm}^2$

17. Multiply or divide as indicated watching sig figs.
   a. $(6.2 \times 10^{18}\ \text{m})(4.7 \times 10^{-10}\ \text{m})$
   b. $\dfrac{5.6 \times 10^{-7}}{2.8 \times 10^{-12}\ \text{s}}$
   c. $\dfrac{6.5 \times 10^{5}\ \text{kg}}{3.4 \times 10^{3}\ \text{m}^3}$

AP Physics

Dimensional Analysis Worksheet

The following are dimensions of various physical parameters that will be discussed later on in the text. Here [L], [T], and [M] denote, respectively, dimensions of length, time, and mass.

	Dimension		Dimension
Distance (x)	[L]	Acceleration (a)	$[L]/[T]^2$
Time (t)	[T]	Force (F)	$[M][L]/[T]^2$
Mass (m)	[M]	Energy (E)	$[M][L]^2/[T]^2$
Speed (v)	[L]/[T]		

Which of the following equations are dimensionally correct?

1. $v_2 = v_1 t + a$

2. $v_f = (v_1 + v_2)/2$

3. $x = vt^2 + (1/2)at$

4. $v_2^2 = v_1^2 + 2ax^2$

5. $x = (1/2)vt^2 + at$

6. $F = ma$

7. $x = (1/2)at^2$

8. $E = (1/2)mv$

9. $E = max$

10. $v = \sqrt{Fx/m}$

11. A spring is hanging down from the ceiling and an object of mass m is attached to the free end. The object oscillates up and down, and the time T required for one complete up-and-down oscillation is given by the equation $T = 2\pi\sqrt{m/k}$, where k is known as the spring constant. What must be the dimension of k for this equation to be dimensionally correct?

AP Physics

Math Review & Vectors Worksheet

Unit Conversion

1. The largest diamond ever found had a size of 3106 carats. One carat is equivalent to a mass of 0.200 g. Use the fact that 1 kg (1000 g) has a weight of 2.205 lb under certain conditions, and determine the weight of this diamond in pounds.

2. Vesna Vulovic survived the longest fall on record without a parachute when her plane exploded and she fell 6 miles, 551 yards. What is this distance in meters?

3. Bicyclists in the Tour de France reach speeds of 34.0 miles per hour (mi/h) on flat sections of the road. What is this speed in (a) kilometers per hour (km/h) and (b) meters per second (m/s)?

4. Azelastine hydrochloride is an antihistamine nasal spray. A standard size container holds one fluid ounce (oz) of the liquid. You are searching for this medication in a European drugstore and are asked how many milliliters (mL) there are in one fluid ounce. Using the following conversion factors, determine the number of milliliters in a volume of one fluid ounce: 1 gallon (gal) = 128 oz, 3.785×10^{-3} cubic meters (m^3) = 1 gal, and 1 mL = 10^{-6} m^3.

5. The mass of the parasitic wasp *Caraphractus cintus* can be as small as 5×10^{-6} kg. What is this mass in (a) grams (g), (b) milligrams (mg), and (c) micrograms (μg)?

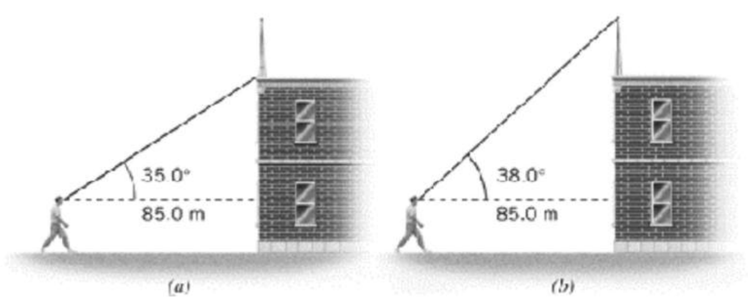
Trigonometry

6. You are driving into St. Louis, Missouri, and in the distance you see the famous Gateway-to-the-West arch. This monument rises to a height of 192 m. You estimate your line of sight with the top of the arch to be 2.0° above the horizontal. Approximately how far (in kilometers) are you from the base of thearch?

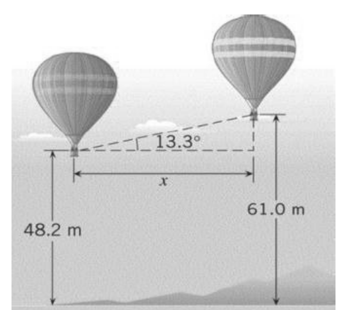
7. The gondola ski lift at Keystone, Colorado, is 2830 m long. On average, the ski lift rises 14.6° above the horizontal. How high is the top of the ski lift relative to the base?

8. A highway is to be built between two towns, one of which lies 35.0 km south and 72.0 km west of the other. What is the shortest length of highway that can be built between the two towns, and at what angle would this highway be directed with respect to due west?

9. The drawing shows a person looking at a building on top of which an antenna is mounted. The horizontal distance between the person's eyes and the building is 85.0 m. In part *a* the person is looking at the base of the antenna, and his line of sight makes an angle of 35.0° with the horizontal. In part *b* the person is looking at the top of the antenna, and his line of sight makes an angle of 38.0° with the horizontal. How tall is the antenna?



For Problem 9



For Problem 10