AP 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. Understanding the main concepts of the following topics and how they relate to your everyday experience is the best way to learn the content for this class.

Kinematics: 1D, 2D, & 3D Motion with Calculus
Force & Motion (Newton’s Laws of Motion)
Work, Power, and Energy
Systems of Particles & Linear Momentum
Rotational Kinematics, Energy, & Angular Momentum
Oscillations
Gravitation

There are not a lot of concepts covered in this class but you do have to thoroughly understand the concepts to apply your understanding to unique problems. The level of problem solving in this class is probably going to be at a higher level than what you have previously experienced.

The purpose of this packet is to review some of the mathematical concepts used in AP Physics as well as introduce some of the basic vocabulary used in the first unit.

ASSIGNMENT:
1. Math Review Worksheets
   a. Sig Fig & Units Worksheet
   b. Dimensional Analysis Worksheet
   c. Math Review & Vectors Worksheet

If you have any questions, feel free to email me: cheryl.carmean@gacps.org

Have a fun and restful summer!
**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 x 10^6 m  
- Bohr radius of H atom = 0.000000000529 m = 5.29 x 10^{-11} m

All scientific notations are composed of an integer (0 < m ≤ 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:

```
EE or Exp
```

Example:  
6.38 x 10^6 : 6.38 EE 6 = 6.38E6 (the scientific notation on the calculator)

**NOTE:** Do not punch 6.38 X 10 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](image)
   ![Has 1 decimal place](image)

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](image)
   ![Has 4 sig figs](image)

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

<table>
<thead>
<tr>
<th>SI</th>
<th>CGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Meter (m)</td>
</tr>
<tr>
<td>Mass</td>
<td>Kilogram (kg)</td>
</tr>
<tr>
<td>Time</td>
<td>Second (s)</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>symbol</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>tera</td>
<td>T</td>
<td>$10^{12}$</td>
</tr>
<tr>
<td>giga</td>
<td>G</td>
<td>$10^9$</td>
</tr>
<tr>
<td>mega</td>
<td>M</td>
<td>$10^6$</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>$10^3$</td>
</tr>
<tr>
<td>deci</td>
<td>d</td>
<td>$10^{-1}$</td>
</tr>
<tr>
<td>centi</td>
<td>c</td>
<td>$10^{-2}$</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>micro</td>
<td>μ</td>
<td>$10^{-6}$</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>$10^{-9}$</td>
</tr>
<tr>
<td>pico</td>
<td>p</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>femto</td>
<td>f</td>
<td>$10^{-15}$</td>
</tr>
</tbody>
</table>

Other conversion factors you should know:

<table>
<thead>
<tr>
<th>Conversion Factor</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 h = 3600 s</td>
<td>1 yr = 365.24 days</td>
</tr>
<tr>
<td>1 in = 2.54 cm</td>
<td>1 kg = 2.205 lb</td>
</tr>
<tr>
<td>1 m = 3.281 ft</td>
<td>1 m³ = 1000 L</td>
</tr>
<tr>
<td>1 mile = 5280 ft</td>
<td>1.609 km</td>
</tr>
</tbody>
</table>

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.

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

\[
979.0 \text{ m} \times \frac{3.281 \text{ ft}}{1 \text{ m}} = 3212 \text{ ft}
\]
**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.

\[
\begin{align*}
x &= (1/2)vt^2 \\
[L] &= \frac{L}{T^2} [T]^2 = [L][T]
\end{align*}
\]

\[
\begin{align*}
x &= (1/2)vt \\
[L] &= \frac{L}{T} [T] = [L]
\end{align*}
\]

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: \( v = v_0 + at \).

\[
\begin{align*}
v &= v_0 + at \\
v - v_0 &= at \\
\frac{(v - v_0)}{a} &= t
\end{align*}
\]

Make sure you are comfortable with manipulating equations.

**Trigonometry**

Know the basic trig functions: sine, cosine, tangent

\[
\begin{align*}
sin \theta &= \text{opposite/hypotenuse} \\
cos \theta &= \text{adjacent/hypotenuse} \\
tan \theta &= \text{opposite/adjacent}
\end{align*}
\]

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. 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 2\textsuperscript{nd} vector at the head of the 1\textsuperscript{st} vector

Ex: Add the following 2 vectors:

\[
\begin{align*}
A &= 200 \text{ m} \\
B &= 100 \text{ m}
\end{align*}
\]

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.

\[
\begin{align*}
R &= A + B \\
R &= +275 \text{ m} + (+125 \text{ m}) = +400 \text{ m} \\
R &= 400 \text{ m}, \text{ due east}
\end{align*}
\]

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

\[
\begin{align*}
R &= A + C \\
R &= +275 \text{ m} + (-125 \text{ m}) = +150 \text{ m} \\
R &= 150 \text{ m}, \text{ due east}
\end{align*}
\]

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.**
Ex: What is the magnitude and direction of \( R \)?

\[
R^2 = A^2 + B^2
\]
\[
R^2 = (200. \text{ m})^2 + (200. \text{ m})^2
\]
\[
R = 283 \text{ m}
\]
\[
\tan \theta = \text{opp/adj} = 200. \text{ m}/200. \text{ m} = 1
\]
\[
\theta = 45^\circ
\]
\[
R = 283 \text{ m}, 45^\circ \text{ N of E}
\]

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
\[
Ax = Acos \theta
\]

**y-component:** vector component that’s parallel to \( y \)-axis
\[
Ay = Asin \theta
\]

Steps To Adding Non-Perpendicular Vectors:
Ex: Add the following vectors:
\( A = 50.0 \text{ m/s}, 30.0^\circ \text{ S of E} \)
\( B = 25.0 \text{ m/s}, 75.0^\circ \text{ S of W} \)

**Step 1:** Resolve (breakdown) each vector into its \( x \)- and \( y \)-components.
\[
Ax = (50.0 \text{ m/s})(\cos 30.0^\circ) = +43.3 \text{ m/s}
\]
\[
Ay = (50.0 \text{ m/s})(\sin 30.0^\circ) = -25.0 \text{ m/s}
\]
\[
Bx = (25.0 \text{ m/s})(\cos 75.0^\circ) = -6.47 \text{ m/s}
\]
\[
By = (25.0 \text{ m/s})(\sin 75.0^\circ) = -24.1 \text{ m/s}
\]

**Step 2:** Add all the \( x \)-components. Add all the \( y \)-components.
\[
Rx = Ax + Bx
\]
\[
Rx = +43.3 \text{ m/s} + (-6.47 \text{ m/s})
\]
\[
Rx = +36.8 \text{ m/s}
\]
\[
Ry = Ay + By
\]
\[
Ry = -25.0 \text{ m/s} + (-24.1 \text{ m/s})
\]
\[
Ry = -49.1 \text{ m/s}
\]
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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.

\[
\begin{align*}
R_x &
\end{align*}
\]

\[
\begin{align*}
R_y &
\end{align*}
\]

Step 4: Use Pythagorean Theorem to calculate the magnitude of the resultant.
\[
R^2 = R_x^2 + R_y^2
\]
\[
R^2 = (36.8 \text{ m/s})^2 + (-49.1 \text{ m/s})^2
\]
\[
R = 61.4 \text{ m/s}
\]

Step 5: Use trig to determine the direction of the resultant. **Make sure calculator is in DEGREE mode.
\[
\begin{align*}
\tan \theta = \frac{\text{opp}}{\text{adj}} &= \frac{R_y}{R_x} = \frac{49.1}{36.8} \\
\theta &= 53.1^\circ \text{ S of E}
\end{align*}
\]

**Answer: Resultant Vector = 61.4 m/s, 53.1^\circ \text{ 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.
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. $3.040 \times 10^5$ ______

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. $2.997 \times 10^{10}$ ______________________
   e. $6.02 \times 10^{-5}$ ______________________
   f. $2.5359 \times 10^2$ ______________________

3. In the following, how many decimal places will the solution have? DO NOT SOLVE.
   a. $6.0 \text{ m} + 10.73 \text{ m} + 111.250 \text{ m}$
   b. $4050 \text{ L} - 2.06 \text{ L}$
   c. $96.75 \text{ km} + 108.43 \text{ km} + 77 \text{ km}$
   d. $93.4 \text{ cm} + 10.975 \text{ cm}$
   e. $0.005070 \text{ cm} + 6.90 \text{ cm} + 2000.860 \text{ cm}$
   f. $10.970 \text{ mL} - 5.0 \text{ mL}$

4. In the following, how many digits should be in the solution to have the proper number of sig figs? DO NOT SOLVE.
   a. $(797.6 \text{ m})(54 \text{ m})$
   b. $(851 \text{ cm})(24.3 \text{ cm})$
   c. $1075 \text{ kg} ÷ 15 \text{ L}$
   d. $93.4 \div 10.975 \text{ m}$
   e. $(6.02 \times 10^{23} \text{ m})(12.00 \text{ m})(1.660 \times 10^{-24} \text{ m})$
   f. $(453.6 \text{ m})(9.050 \times 10^4 \text{ m})(239.1 \text{ m})$

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 $2.25 \times 10^6 \text{ cm}^3$, 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
d. 0.023 mm
   b. 6.2 pm
e. 214 μm
   c. 21 km
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 x 10^5 kg
    b. 6 x 10^5 kg
c. 4.07 x 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 cm^2 – 32.046 cm^2

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

<table>
<thead>
<tr>
<th>Distance (x)</th>
<th>Dimension ([L])</th>
<th>Acceleration (a)</th>
<th>Dimension ([L]/[T]^2])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (t)</td>
<td>([T])</td>
<td>Force (F)</td>
<td>([M][L]/[T]^2])</td>
</tr>
<tr>
<td>Mass (m)</td>
<td>([M])</td>
<td>Energy (E)</td>
<td>([M][L]^2/[T]^2])</td>
</tr>
<tr>
<td>Speed (v)</td>
<td>([L]/[T])</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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. \(E = mx\)

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?
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 x 10^{-3} cubic meters (m^3) = 1 gal, and 1 mL = 10^{-6} m^3.

5. The mass of the parasitic wasp Caraphyractus cintus can be as small as 5 x 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 the arch?

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
10. The two hot-air balloons in the drawing are 48.2 and 61.0 m above the ground. A person in the left balloon observes that the right balloon is 13.3° above the horizontal. What is the horizontal distance \( x \) between the two balloons?

11. The drawing shows sodium and chloride ions positioned at the corners of a cube that is part of the crystal structure of sodium chloride (common table salt). The edge of the cube is 0.281 nm in length. Find the distance (in nanometers) between the sodium ion located at one corner of the cube and the chloride ion located on the diagonal at the opposite corner.

12. What is the value of the angle \( \theta \) in the drawing that accompanies problem 11?

Vector Addition and Subtraction

13. (a) Two workers are trying to move a heavy crate. One pushes on the crate with a force \( \vec{A} \), which has a magnitude of 445 newtons and is directed due west. The other pushes with a force \( \vec{B} \), which has a magnitude of 325 newtons and is directed due north. What are the magnitude and direction of the resultant force \( \vec{A} + \vec{B} \) applied to the crate? (b) Suppose that the second worker applies a force \( -\vec{B} \) instead of \( \vec{B} \). What then are the magnitude and direction of the resultant force \( \vec{A} - \vec{B} \) applied to the crate? In both cases express the direction relative to due west.

14. Consider the following four force vectors:
   \[ \vec{F}_1 = 50.0 \text{ newtons, due east} \]
   \[ \vec{F}_2 = 10.0 \text{ newtons, due east} \]
   \[ \vec{F}_3 = 40.0 \text{ newtons, due west} \]
   \[ \vec{F}_4 = 30.0 \text{ newtons, due west} \]
Which two vectors add together to give a resultant with the smallest magnitude, and which two vectors add to give a resultant with the largest magnitude? In each case specify the magnitude and direction of the resultant.

15. A circus performer begins his act by walking out along a nearly horizontal high wire. He slips and falls to the safety net, 25.0 ft below. The magnitude of his displacement from the beginning of the walk to the net is 26.7 ft. (a) How far out along the high wire did he walk? (b) Find the angle that his displacement vector makes below the horizontal.

16. The drawing shows a triple jump on a checkerboard, starting at the center of square A and ending on the center of square B. Each side of a square measures 4.0 cm. What is the magnitude of the displacement of the colored checker during the triple jump?

17. One displacement vector \( \vec{A} \) has a magnitude of 2.43 km and points due north. A second displacement vector \( \vec{B} \) has a magnitude of 7.74 km and also points due north. (a) Find the magnitude and direction of \( \vec{A} - \vec{B} \). (b) Find the magnitude and direction of \( \vec{B} - \vec{A} \).

18. Two bicyclists, starting at the same place, are riding toward the same campground by two different routes. One cyclist rides 1080 m due east and then turns due north and travels another 1430 m before reaching the campground. The second cyclist starts out by heading due north for
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1950 m and then turns and heads directly toward the campground. (a) At the turning point, how far is the second cyclist from the campground? (b) What direction (measured relative to due east) must the second cyclist head during the last part of the trip?

Vector Components

19. Vector \( \vec{A} \) points along the + y axis and has a magnitude of 100.0 units. Vector \( \vec{B} \) points at an angle of 60.0° above the + x axis and has a magnitude of 200.0 units. Vector \( \vec{C} \) points along the + x axis and has a magnitude of 150.0 units. Which vector has (a) the largest x component and (b) the largest y component.

20. Your friend has slipped and fallen. To help her up, you pull with a force \( \vec{F} \), as the drawing shows. The vertical component of this force is 130 newtons, and the horizontal component is 150 newtons. Find (a) the magnitude of \( \vec{F} \) and (b) the angle.

21. An ocean liner leaves New York City and travels 18.0° north of east for 155 km. How far east and how far north has it gone? In other words, what are the magnitudes of the components of the ship’s displacement vector in the directions (a) due east and (b) due north?

22. Soccer player #1 is 8.6 m from the goal (see the drawing). If she kicks the ball directly into the net, the ball has a displacement labeled \( \vec{A} \). If, on the other hand, she first kicks it to player #2, who then kicks it into the net, the ball undergoes two successive displacements, \( \vec{A}_v \) and \( \vec{A}_x \). What are the magnitudes and directions of \( \vec{A}_v \) and \( \vec{A}_x \)?

Addition of Vectors with Components

23. Two forces are applied to a tree stump to pull it out of the ground. Force \( \vec{F}_A \) has a magnitude of 2240 newtons and points 34.0° south of east, while force \( \vec{F}_B \) has a magnitude of 3160 newtons and points due south. Using the component method, find the magnitude and direction of the resultant force \( \vec{F}_A + \vec{F}_B \) that is applied to the stump. Specify the direction with respect to due east.

24. A golfer, putting on a green, requires three strokes to “hole the ball.” During the first putt, the ball rolls 5.0 m due east. For the second putt, the ball travels 2.1 m at an angle of 20.0° north of east. The third putt is 0.50 m due north. What displacement (magnitude and direction relative to due east) would have been needed to “hole the ball” on the very first putt?

25. The magnitudes of the four displacement vectors shown in the drawing are \( A = 16.0 \) m, \( B = 11.0 \) m, \( C = 12.0 \) m, and \( D = 26.0 \) m. Determine the magnitude and directional angle for the resultant that occurs when these vectors are added together.

For Problem 25

For Problem 26
26. A baby elephant is stuck in a mud hole. To help pull it out, game keepers use a rope to apply force $\mathbf{F}_A$, as part $a$ of the drawing shows. By itself, however, force $\mathbf{F}_A$ is insufficient. Therefore, two additional forces $\mathbf{F}_B$ and $\mathbf{F}_C$ are applied, as in part $b$ of the drawing. Each of these additional forces has the same magnitude $F$. The magnitude of the resultant force acting on the elephant in part $b$ of the drawing is twice that in part $a$. Find the ratio $F/F_A$.

Mixed Problems

27. A chimpanzee sitting against his favorite tree gets up and walks 51 m due east and 39 m due south to reach a termite mound, where he eats lunch. (a) What is the shortest distance between the tree and the termite mound? (b) What angle does the shortest distance make with respect to due east?

28. An observer, whose eyes are 1.83 m above the ground, is standing 32.0 m away from a tree. The ground is level, and the tree is growing perpendicular to it. The observer’s line of sight with the treetop makes an angle of $20.0^\circ$ above the horizontal. How tall is the tree?

29. The speed of an object and the direction in which it moves constitute a vector quantity known as the velocity. An ostrich is running at a speed of 17.0 m/s in a direction of $68.0^\circ$ north of west. What is the magnitude of the ostrich’s velocity component that is directed (a) due north and (b) due west?

30. The variables $x$, $v$, and $a$ have the dimensions of $[L]$, $[L]/[T]$, and $[L]/[T]^2$, respectively. These variables are related by an equation that has the form $v^n = 2ax$, where $n$ is an integer constant (1, 2, 3, etc.) without dimensions. What must be the value of $n$, so that both sides of the equation have the same dimensions? Explain your reasoning.

31. You are on a treasure hunt and your map says “Walk due west for 52 paces, then walk 30.0$^\circ$ north of west for 42 paces, and finally walk due north for 25 paces.” What is the magnitude of the component of your displacement in the direction (a) due north and (b) due west?

32. Displacement vector $\mathbf{A}$ points due east and has a magnitude of 2.00 km. Displacement vector $\mathbf{B}$ points due north and has a magnitude of 3.75 km. Displacement vector $\mathbf{C}$ points due west and has a magnitude of 2.50 km. Displacement vector $\mathbf{D}$ points due south and has a magnitude of 3.00 km. Find the magnitude and direction (relative to due west) of the resultant vector $\mathbf{A} + \mathbf{B} + \mathbf{C} + \mathbf{D}$.

33. Two ropes are attached to a heavy box to pull it along the floor. One rope applies a force of 475 Newtons in a direction due west; the other applies a force of 315 Newtons in a direction due south. As we will see later in the text, force is a vector quantity. (a) How much force should be applied by a single rope, and (b) in what direction (relative to due west), if it is to accomplish the same effect as the two forces added together?

34. A force vector points at an angle of $52^\circ$ above the $+x$ axis. It has a $y$-component of $+290$ newtons. Find (a) the magnitude and (b) the $x$ component of the force vector.

35. Vector $\mathbf{A}$ has a magnitude of 6.00 units and points due east. Vector $\mathbf{B}$ points due north. (a) What is the magnitude of $\mathbf{B}$, if the vector $\mathbf{A} + \mathbf{B}$ points $60.0^\circ$ north of east? (b) Find the magnitude of $\mathbf{A} + \mathbf{B}$. 
Notes Organizer: Chapter 2 - Kinematics in 1D

**Mechanics**: A branch of physics

\[
\text{Statics} + \text{Dynamics} = \text{Mechanics}
\]

Def: [ ]

Def: [ ]

**Note**: The first 10 chapters of our book deals with Mechanics.

**Displacement**
- Definition:
- Unit:

→ Distance: similar to displacement, but doesn’t have a direction.

Therefore: Displacement is a ______ quantity and distance is a ______ quantity.

**Speed vs. Velocity**

*Speed*
- Definition:
- Unit:
- Equation:

*Average Velocity*
- Definition:
- Unit:
- Equation:

→ How are speed and velocity the same? How are they different?

*Instantaneous Velocity*

Definition:

→ How is instantaneous velocity different from average velocity?

Example:
Acceleration

- Definition:
- Unit:
- Equation:
- Vector or Scalar?

→ How are acceleration and velocity related? How does the directions of acceleration and velocity affect each other?

→ Compare and contrast instantaneous/constant/average accelerations:

Kinematics Equations

**For AP Physics B, we will focus on constant acceleration situations only.

The 4 Kinematics Equations:

Meaning of the symbols used:

\( x: \) \( v_0: \)
\( x_0: \) \( v: \)
\( a: \) \( t: \)

Applying Kinematics Equations:

Problem-Solving Tips:
1. Decide which direction is positive and negative.
2. Write down your gives. What are known values, unknown values. List them down as variables. If unknown, use question marks to identify it as an unknown.

Example: \( x = 5 \text{ m} \)
\( a = +2.0 \text{ m/s}^2 \)
\( v_0 = 0 \text{ m/s} \)
\( t =? \)

**sometimes, two different scenarios will be given. Label each given according to each scenario.
3. Identify which equation will be best to use to calculate for the unknown. Write this equation down before solving.
4. Solve the problem by plugging in the numbers and computing using math.
5. Box your final answer. DO NOT forget about units.

→ What is the difference between deceleration and negative acceleration? Give examples to justify your answer.

**Graphical Analysis of Velocity & Acceleration**

Graphs tell us a lot of information about motion.

**Position-Time Graph**

- x-axis:
- y-axis:
- slope:
  - example: (draw a graph to illustrate the following)
    constant positive velocity | constant negative velocity | zero velocity

**Velocity-Time Graph**

- x-axis:
- y-axis:
- slope:
- area under the curve:
  - example: (draw a graph to illustrate the following)
    constant pos acceleration | constant neg acceleration | zero acceleration

→ How would you graph the follow so that it would be a straight-line graph? Identify which quantity/variable will be on the x-axis and on the y-axis.

\[ v = v_0 + at \]
\[ x = vt \]
\[ x = \frac{1}{2}at^2 \]
\[ v^2 = v_0^2 + 2ax \]