Honors Physical Science

Name ______________________________

Skills Review and Summer Work

I. Honors Physical Science is intended to match the rigor of a high-school Physics class, and as such requires a proficiency in algebra, geometry and some trigonometry (which can be introduced as needed). A proper foundation for this class includes knowing how to work with units by applying dimensional analysis and unit conversions, how to represent measured numbers using significant figures and rounding rules (including scientific notation), as well as a variety of algebra and geometry skills.

II. The exercises and activities in this packet contain both math review problems and links to physical science tutorials online. It is hoped that this review material, (combined with your previous math and science knowledge), will give you a head start to the Honors Physical Science curriculum.

III. What if I don't get all the problems or don't understand the instructions?

A. Do the best you can, but show some work / effort in order to receive credit.

B. You can communicate with me (Daniel Beck) via email: dbeck@fenwickfalcons.org

C. Come to the first class with your questions about anything you weren't able to figure out. It is as important to know what you don't yet know, as it is to have mastered these skills, so that I can help direct your learning to the most needed areas.

D. In areas where most of the class had difficulty or lots of questions, we will use class time to review/explain and give additional examples, and you will have an opportunity to fix errors or gaps in knowledge BEFORE turning in the packet for credit.

E. Many students usually understand and remember a LITTLE about right triangle relationships (sine, cosine, tangent and the Pythagorean Theorem. In Part 4 of this packet there are exercises to review this as a skill. Where we need to use this most is with finding and adding vector components in Part 5 of the packet. If this is a step beyond what you can figure out on your own, DON'T WORRY—we'll cover these relationships gradually in 1st quarter. Please watch the tutorials and Part 5 if you can figure it out, but I'll only consider up through Part 4 for grading of this Summer Packet, and as III D above points out, you'll have a chance to fix errors and gaps in knowledge through that point. In other words, Part 5 is NOT optional and you still need to try it, but it won't count against you if you have trouble getting through it.

Part 1: Unit Conversions: Scientists all over the world use the same system of units so they can communicate information clearly. This system of measurement is called the **International System of Units (SI)**. Metric measurement is based on the number ten and makes calculations with the system relatively easy.

1000	100	10	1	1/10	1/100	1/1000
Kilo-	**Hecto-**	**Deca-**	_____	**deci-**	**centi-**	**milli-**

The blank line in the middle of the conversion chart can change depending on what we are measuring:
The unit for length is the **meter** (m). The unit for mass is the **gram** (g). The unit for volume is the **liter** (L). So 25 cm is the same as 25 x [1/100] m = 0.25 m. Or 30 kL is the same as 30 x [1000] L = 30000 L. As you might suspect, this is even easier to do if we express our powers of 10 using scientific notation. Then you just need to move decimal points the same spacing as the exponent of 10. We'll see more of this later.

PART A

Can you identify each unit with its symbol? What type of measurement is indicated by each of the following units? Choices include density, length, mass, time, and volume.

1. g/mL _____________ 4. g _____________ 7. mg _____________
2. s _____________ 5. cm^3 _____________ 8. L _____________
3. km _____________ 6. mm _____________ 9. g/cm^3 _____________

PART B

1. Physics usually uses the ***MKS*** system, a variation of the SI units. ***MKS*** stands for meter, kilogram, second. These are the most useful choice of units for physics. While equations themselves are universal relationships, their actual solutions in physics (and physical science) depend on unit agreement. An infamous example of this occurred in 1999, when NASA lost its $125 million Mars Climate Observer space probe because the navigation specialists at the Jet Propulsion Laboratory expected metric units for calibrating the impulse of orbital thrusters in Newton-seconds, but the space probe's builder, Lockheed Martin, provided the impulse data in English units of pound-seconds. The wrong instructions got sent to the spacecraft, and it burned up in Mar's atmosphere instead of entering orbit as planned.
2. Moral of the story: You <u>must</u> convert to ***MKS*** in most problems to arrive at the correct answer. Skipping writing down units in working out problems is almost always a bad idea, because inconsistent units reveal mistakes that just seeing numbers will not reveal. I take off points for incorrect or missing units on problems, so it is important to use them throughout your problem solving efforts.
3. Some common metric conversions include:

kilometers (*km*) to/from meters (*m*)	gram (*g*) to/from kilogram (*kg*)
centimeters (*cm*) to/from meters (*m*)	Celsius (^oC) to/from Kelvin (*K*)
millimeters (*mm*) to/from meters (*m*)	square millimeters (mm^2) to/from square meters (m^2)
nanometers (*nm*) to/from meters (*m*)	cubic centimeters (cm^3) to/from cubic meters (m^3) or Liters (L)
micrometers (μm) to/from meters (*m*)	Other conversions will be encountered as they occur.

What if you don't know the conversion factors? Colleges want students who can find their own information (so do employers). Hint: Siri, Alexa and Google can help with this, and free conversion apps are easy to find, so please take the initiative to find what you need and LOOK it up. After some practice, you'll know the most important conversions without having to look them up. Try these to get a start on this skill:

1000 mg = _____ g	198 g = _____ kg	8 mm = _____ cm
160 cm = _____ mm	75 mL = _____ L	6.3 cm = _____ mm
109 g = _____ kg	50 cm = _____ m	5.6 m = _____ cm
250 m = _____ Km	5 L = _____mL	26,000 cm = _____ m
14 Km = _____ m	16 cm = _____mm	56,500 mm = _____ km
1 L = _____ mL	65 g = _____ mg	27.5 mg = _____ g
480 cm = _____ m	2500 m = _____ km	923 cm = _____ m
27 g = _____ kg	355 mL = _____ L	0.025 Km = _____ cm

Part 2: Dimensional Analysis:

First, go to this URL and review a video that lays out the reasoning involved with dimensional analysis and why it is useful, with examples to try: https://www.khanacademy.org/math/algebra/units-in-modeling/rate-conversion/v/dimensional-analysis-units-algebraically

Next, go to this URL, which simplifies the explanations a bit but provides some wonderful examples to look over: http://www.alysion.org/dimensional/fun.htm

Using either of the above approaches, convert the following values into the requested units: Please show all of your work!

a. 1.42 g/cm^2 to mg/mm^2

b. 10095 m/s to miles/hour

c. 9.81 m/s^2 to ft/s^2

d. 8.41 g/mL to kg/L

e. 25 mph to m/s

2. The following are ordinary physics problems. Show the reasoning needed to cancel out, convert and simplify units in order to arrive at the requested unit in your answer.

f. Traveling at 65 miles/hour, how many minutes will it take to drive 125 miles to San Diego?

g. Traveling at 65 miles/hour, how many feet can you travel in 22 minutes?

h. Sally Leadfoot was pulled over on her way from Syracuse to Ithaca by an officer claiming she was speeding. The speed limit is 65 mi/hr and Sally had traveled 97 km in 102 minutes. How fast was Sally's average speed? Does she deserve a ticket?

i. An airplane is cruising at a steady speed of 500 mph. How far will it go, in kilometers, if it maintains the same speed and direction for 3 hours?

For this part, review the scientific notation video at https://www.khanacademy.org/math/pre-algebra/pre-algebra-exponents-radicals/pre-algebra-scientific-notation/v/scientific-notation and return to try the rest:

Convert the following numbers into scientific notation:

1) 3,400 ______________________________

2) 0.000023 ______________________________

3) 101,000 ______________________________

4) 0.010 ______________________________

5) 45.01 ______________________________

6) 1,000,000 ______________________________

7) 0.00671 ______________________________

8) 4.50 ______________________________

Convert the following numbers into standard notation:

9) 2.30×10^{4} ______________________________

10) 1.76×10^{-3} ______________________________

11) 1.901×10^{-7} ______________________________

12) 8.65×10^{-1} ______________________________

13) 9.11×10^{3} ______________________________

14) 5.40×10^{1} ______________________________

15) 1.76×10^{0} ______________________________

16) 7.4×10^{-5} ______________________________

Now convert the units correctly, keeping the answer in scientific notation:

17) 8.8×10^{-8} *m* = ______________________________ *mm*

18) 6.23×10^{-7} *m* = ______________________________ *nm*

19) 1.5×10^{11} *m* = ______________________________ *km*

20) 2.5×10^{-3} m^2 = ______________________________ mm^2

21) 5.70×10^{-3} *L* = ______________________________ cm^3

Part 3: Applications of Dimensional Analysis and Scientific Notation:

1. Here are some physics equations with numbers in scientific notation already in place. Evaluate these expressions with a scientific calculator and round the answer to 2 significant figures, using the correct units. Don't worry if you don't recognize the units—they still cancel out and simplify using the rules of dimensional analysis you learned above.

a. $T_s = 2\pi\sqrt{\dfrac{4.5\times10^{-2}\,kg}{2.0\times10^{3}\,kg/s^2}} = ?$ _______________

b. $K = \frac{1}{2}\left(6.6\times10^{2}\ kg\right)\left(2.11\times10^{4}\ m/s\right)^2 = ?$ _______________

c. $F = \left(9.0\times10^{9}\,\dfrac{N\cdot m^2}{C^2}\right)\dfrac{\left(3.2\times10^{-9}C\right)\left(9.6\times10^{-9}C\right)}{\left(0.32m\right)^2} = ?$ _______________

d. $\dfrac{1}{R_p} = \dfrac{1}{4.5\times10^{2}\Omega} + \dfrac{1}{9.4\times10^{2}\Omega}$ $R_P = ?$ _______________

(solve for R_p, not $1/R_p$)

e. $e = \dfrac{1.7\times10^{3}\ J - 3.3\times10^{2}\ J}{1.7\times10^{3}\ J} = ?$ _______________%

(this ratio is a percentage, with no units)

f. $K_{max} = \left(6.63\times10^{-34}J\cdot s\right)\left(7.09\times10^{14}s\right) - 2.17\times10^{-19}J\cdot s^2 = ?$ _______________

g. $\gamma = 1\Big/\sqrt{1-\dfrac{2.25\times10^{8}\,m/s}{3.00\times10^{8}\,m/s}} = ?$ _______________

2. Some equations should be solved for the needed variable, before substituting in the known values. Solve for the variable indicated. Don't let the different letters confuse you. Manipulate them algebraically as though they were numbers.

a. $v^2 = v_o^{\ 2} + 2a(s - s_o)$, $a =$ _______________

b. $K = \frac{1}{2}kx^2$, $x =$ _______________

c. $T_p = 2\pi\sqrt{\frac{\ell}{g}}$, $g =$ _______________

d. $F_g = G\frac{m_1 m_2}{r^2}$, $r =$ _______________

e. $mgh = \frac{1}{2}mv^2$, $v =$ _______________

f. $x = x_o + v_o t + \frac{1}{2}at^2$, $t =$ _______________

OR, $t =$ _______________

(hint: the above equation is a quadratic equation—you can skip it if you haven't covered this in a math class yet. Otherwise include both of the possible solutions)

g. $B = \frac{\mu_o}{2\pi}\frac{I}{r}$, $r =$ _______________

h. $x_m = \frac{m\lambda L}{d}$, $d =$ _______________

i. $pV = nRT$, $T =$ _______________

j. $\sin\theta_c = \frac{n_1}{n_2}$, $\theta_c =$ _______________

k. $qV = \frac{1}{2}mv^2$, $v =$ _______________

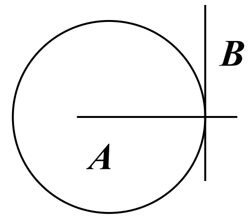
l. $\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$, $s_i =$ _______________

(hint: the above equation needs you to be able to find a common denominator. Review how to do that if it's been a while since you dealt with fractions. But don't give up!)

Part 4: Other useful math skills to know: Solve the following geometric problems. You may need to look up appropriate geometric relation formulas. In physics, we expect you to look up these kinds of things, if needed, without giving them to you as part of a problem description.

a. Line ***B*** touches the circle at a single point. Line ***A*** extends through the center of the circle.

i. What is line ***B*** in reference to the circle?



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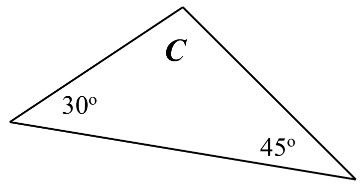
ii. How large is the angle between lines ***A*** and ***B***?

____

b. What is angle ***C***?



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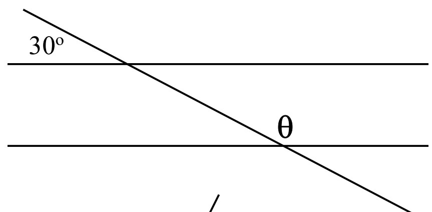
c. What is angle θ ?



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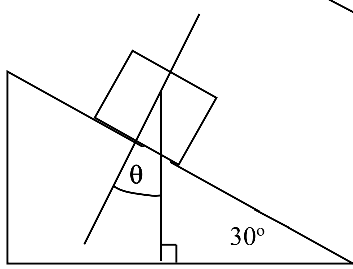
d. How large is *θ*?



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e. The radius of a circle is 5.5 *cm*,

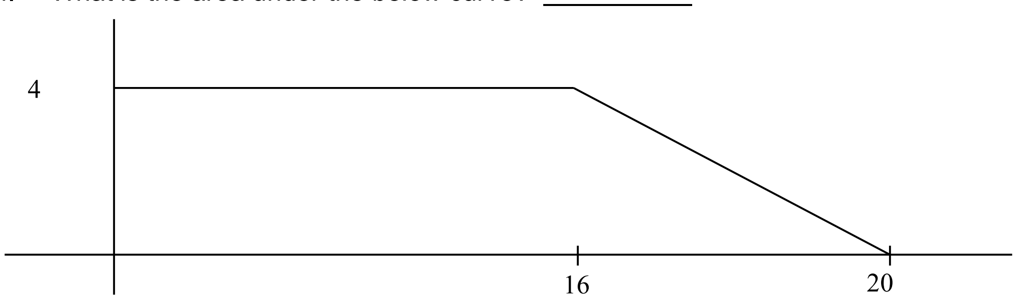
i. What is the circumference in meters?

____

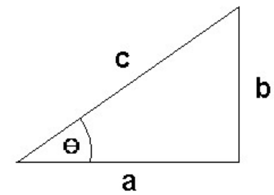
ii. What is its area in square meters?

____

f. What is the area under the below curve? ___________



7. Use the generic right triangle on the side as a reference and apply right triangle geometry and the Pythagorean Theorem to solve the following questions: Please show all necessary reasoning. ***<u>Your calculator must be in degree mode.</u>***



a. θ = 55° and ***c*** = 32 *m*, solve for ***a*** and ***b***.

____

d. ***a*** = 250 *m* and ***b*** = 180 *m*, solve for θ and ***c***.

____

b. θ = 45° and ***a*** = 15 *m/s*, solve for ***b*** and ***c***.

____

e. ***a*** =25 *cm* and ***c*** = 32 *cm*, solve for ***b*** and θ.

____

c. ***b*** = 17.8 *m* and θ = 65°, solve for ***a*** and ***c***.

____

f. ***c*** = 104 *cm* and ***b*** = 65 *cm*, solve for ***a*** and θ.

____

Part 5: Vectors: Most of the quantities in physics are vectors. <u>This makes proficiency in vectors extremely important</u>. We will learn about and use vectors gradually in class, but please look through and try the following examples and problems. [Note: this section won't be graded, but you should still try to get through as much as you can figure out.]

Watch the tutorial on "Intro to vectors and scalars" at the website: https://www.khanacademy.org/test-prep/mcat/physical-processes/vectors-and-scalars/v/introduction-to-vectors-and-scalars

Then, watch the follow up video on the same page called "visualizing vectors in 2 dimensions".

You can skip the lessons on "unit vectors" since we won't be using unit notation at the high school level (You might need to learn them for college, though, and if you take AP Physics with me, you'll get an introduction to them, but they aren't actually part of the AP Physics 1 curriculum.

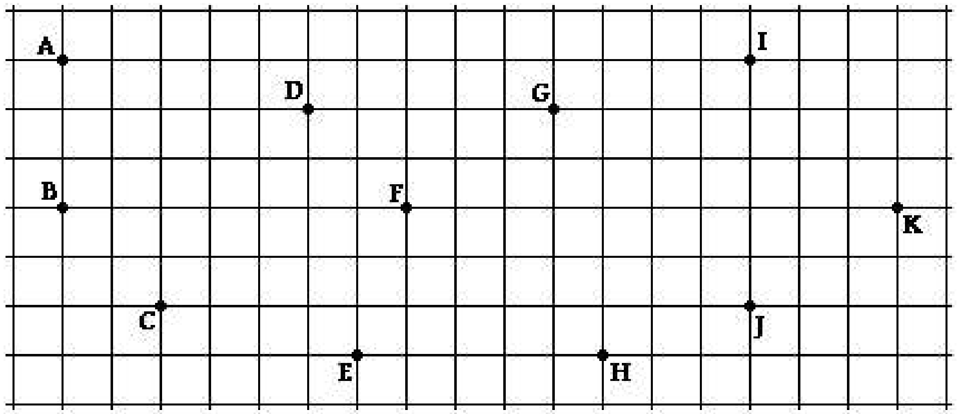
Watch the 2 specified tutorials and then complete the worksheets on the following pages:

Vectors - Fundamentals and Operations

Vectors and Projectiles

For this problem, directions of 2-D vectors can be given in "map" coordinates like for a below: the vector from A to C is south-east or SE. For b: the vector from D to B is south-west or SW, etc.

8. Consider the grid below with several marked locations.



Determine the direction of the resultant displacement for a person who walks from location ...

a. A to C: ____________ b. D to B: ____________ c. G to D: ____________

d. F to A: ____________ e. F to E: ____________ f. C to H: ____________

g. E to K: ____________ h. J to K to F: ____________ i. I to K to B: ____________

9. A short verbal description of a vector quantity is given in each of the descriptions below. Read the description, select a scale, draw a set of axes, and construct a scaled vector diagram to represent the given vector quantity.

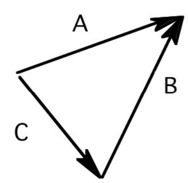
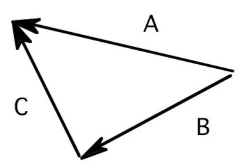
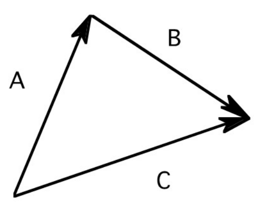
a. Kent Holditnomore excused himself from class, grabbed the cardboard pass off the lecture table, and displaced himself 10 meters at 170°.	b. Marcus Tardee took an extended lunch break and found himself hurrying through the hallways to physics class. After checking in at the attendance office, Marcus moved with an average velocity of 5.0 m/ s at 305°.

For this problem, we are using angle measurements where the 0° angle is in the direction of the + x-axis, with 90° the + y-axis, 270° the -y-axis and 360° back in the +x-axis. This is the standard orientation used in the unit circle used by scientific calculators. Most physics problems involve using this x-y frame of reference for measuring angles.

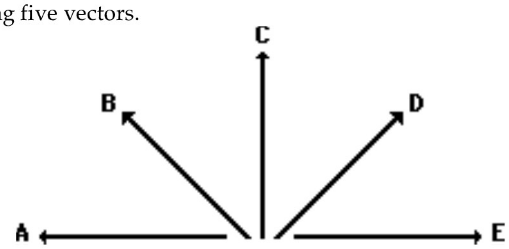
Addition of Vectors

This worksheet was originally paired with tutorials from the PhysicsClassroom; however, links to their tutorials do not currently work. The Khan Academy tutorials referred to earlier should be enough to get you through most of these. The rest we can work out in class.

1. Aaron Agin recently submitted his vector addition homework. As seen below, Aaron added two vectors and drew the resultant. However, Aaron Agin failed to label the resultant on the diagram. For each case, identify the resultant (A, B, or C). Finally, indicate what two vectors Aaron added to achieve this resultant (express as an equation such as X + Y = Z) and approximate the direction of the resultant.

	Resultant is: _______ Vector Eq'n: ________________________________ Dir'n of R: ________________________________
	Resultant is: _______ Vector Eq'n: ________________________________ Dir'n of R: ________________________________
	Resultant is: _______ Vector Eq'n: ________________________________ Dir'n of R: ________________________________

2. Consider the following five vectors.



<u>Sketch</u> the following and draw the resultant (R). Do <u>not</u> draw a scaled vector diagram; merely make a sketch. Label each vector. Clearly label the resultant (R).

A + B + D **A + C + D** **B + C + E**

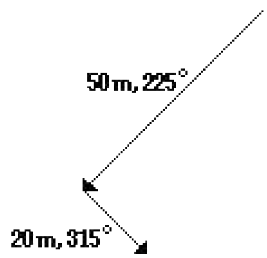
Vectors and Projectiles

Math Skill:

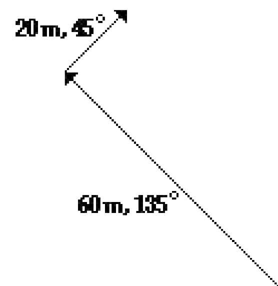
Vectors that make right angles to each other can be added together using Pythagorean theorem. Use Pythagorean theorem to solve the following problems.

3. While Dexter is on a camping trip with his Boy Scout troop, the scout leader gives each boy a compass and a map. Dexter's map contains several sets of directions. For the two sets below, draw and label the resultant (**R**). Then use the Pythagorean theorem to determine the magnitude of the resultant displacement for each set of two directions. **PSYW**

   a. Dexter walked 50 meters at a direction of 225° and then walked 20 meters at a direction of 315°.



   b. Dexter walked 60 meters at a direction of 135° and then walked 20 meters at a direction of 45°.



4. In a classroom lab, a Physics student walks through the hallways making several small displacements to result in a single overall displacement. The listings below show the individual displacements for students A and B. Simplify the collection of displacements into a pair of N-S and E-W displacements. Then use Pythagorean theorem to determine the overall displacement.

Student A	Student B
2 m, North	2 m, North
16 m, East	12 m, West
14 m, South	14 m, South
2 m, West	56 m, West
12 m, South	12 m, South
46 m, West	36 m, East
Σ E-W = ____________	Σ E-W = ____________
Σ N-S = ____________	Σ N-S = ____________
Overall Displacement:	Overall Displacement:

For the problem #3 on this page, only the magnitude of each overall displacement was asked for. For problem #4, use the Pythagorean theorem to find each overall displacement, but specify the direction of each as well. To do this, take the $\tan^{-1}$ (overall y / overall x).

Vector Components, Vector Resolution and Vector Addition

Read from **Lesson 1** of the **Vectors and Motion in Two-Dimensions chapter** at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/vectors/u3l1b.html
http://www.physicsclassroom.com/Class/vectors/u3l1c.html
http://www.physicsclassroom.com/Class/vectors/u3l1eb.cfm

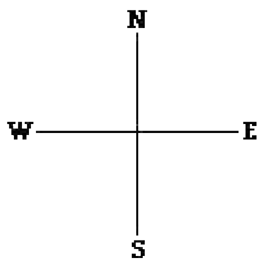
MOP Connection: Vectors and Projectiles: sublevels 3 and 5

Review: The direction of a vector is often expressed as a counter-clockwise (CCW) angle of rotation of that vector from due east (i.e., the horizontal). In such a convention, East is 0°, North is 90°, West is 180° and South is 270°.

About Vector Components:
A vector directed at 120° CCW has a direction which is a little west and a little more north. Such a vector is said to have a northward and a westward component. A **component** is simply the effect of the vector in a given direction. A hiker with a 120° displacement vector is displaced both northward and westward; there are two separate effects of such a displacement upon the hiker.

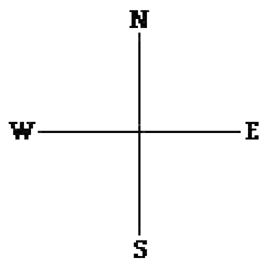
1. Sketch the given vectors; determine the direction of the two components by circling two directions (N, S, E or W). Finally indicate which component (or effect) is greatest in magnitude.

45 km, 300°



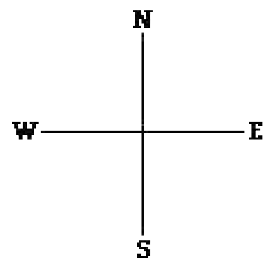
Components: **E W N S**
Greatest magnitude? ______

10 km, 265°



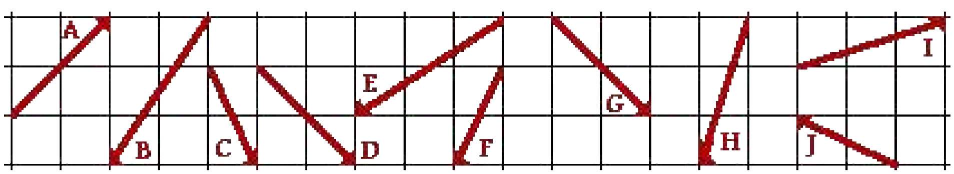
Components: **E W N S**
Greatest magnitude? ______

200 mi, 150°



Components: **E W N S**
Greatest magnitude? ______

2. Consider the various vectors below. Given that each square is 10 km along its edge, determine the magnitude and direction of the components of these vectors.

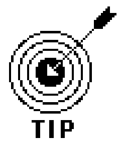


Vector	E-W Component (mag .& dirn')	N-S Component (mag .& dirn')
A		
C		
E		
G		
I		

Vector	E-W Component (mag .& dirn')	N-S Component (mag .& dirn')
B		
D		
F		
H		
J		

Vectors and Projectiles

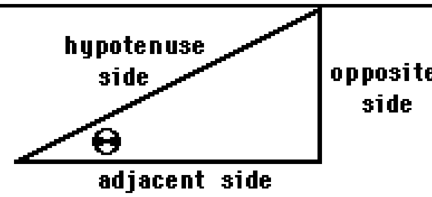
The magnitude of a vector component can be determined using trigonometric functions.



Trigonometry Review

Trigonometric functions are mathematical functions that relate the length of the sides of a right triangle to the angles of the triangle. The meaning of the functions can be easily remembered by the mnemonic

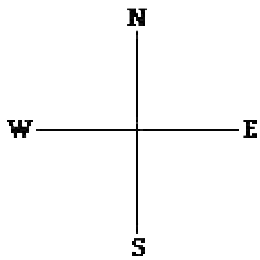
SOH CAH TOA



SOH --> Sin Θ = $\frac{\text{Opposite}}{\text{Hypoteneuse}}$ CAH --> Cos Θ = $\frac{\text{Adjacent}}{\text{Hypoteneuse}}$ TOA --> Tan Θ = $\frac{\text{Opposite}}{\text{Adjacent}}$

3. Sketch the given vectors; project the vector onto the coordinate axes and sketch the components. Then determine the magnitude of the components using SOH CAH TOA.

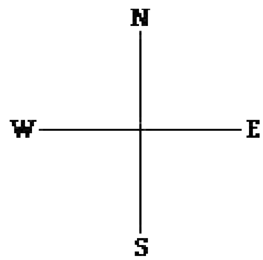
45 km, 300°



E-W Component:

N-S Component:

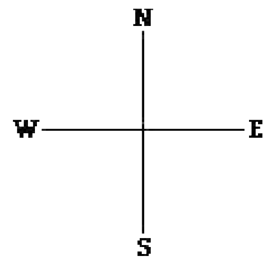
10 km, 265°



E-W Component:

N-S Component:

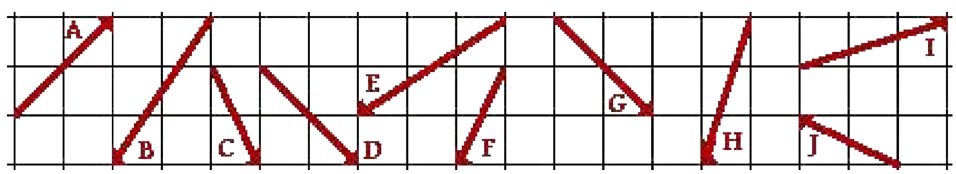
200 mi, 150°



E-W Component:

N-S Component:

4. Consider the diagram below (again); each square is 10 km along its edge. Use components and vector addition to determine the resultant displacement (magnitude only) of the following:



A + B + C ==> Σ E-W: __________ Σ N-S: ___________ Overall Displacement: _____________

D + E + F ==> Σ E-W: __________ Σ N-S: ___________ Overall Displacement: _____________

G + H + I ==> Σ E-W: __________ Σ N-S: ___________ Overall Displacement: _____________

A + J + G ==> Σ E-W: __________ Σ N-S: ___________ Overall Displacement: _____________

Vector Addition by Components

Read from **Lesson 1** of the **Vectors and Motion in Two-Dimensions chapter** at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/vectors/u3l1eb.cfm

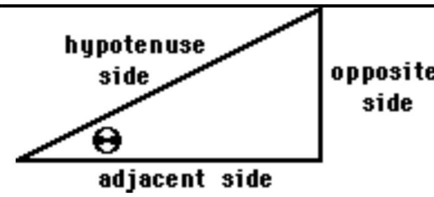
MOP Connection: Vectors and Projectiles: sublevels 3 and 4

TIP

Trigonometry Review

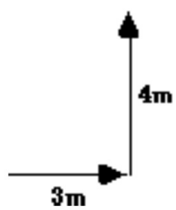
Trigonometric functions are mathematical functions that relate the length of the sides of a right triangle to the angles of the triangle. The meaning of the functions can be easily remembered by the mnemonic

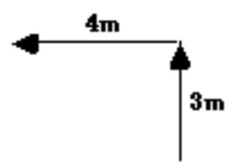
SOH CAH TOA

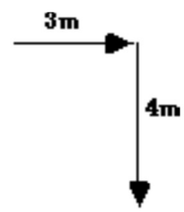


SOH --> **S**in Θ = $\frac{\textbf{O}\text{pposite}}{\textbf{H}\text{ypoteneuse}}$ **CAH** --> **C**os Θ = $\frac{\textbf{A}\text{djacent}}{\textbf{H}\text{ypoteneuse}}$ **TOA** --> **T**an Θ = $\frac{\textbf{O}\text{pposite}}{\textbf{A}\text{djacent}}$

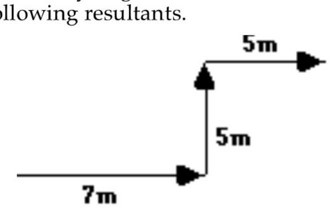
1. For the following vector addition diagrams, use Pythagorean Theorem to determine the magnitude of the resultant. Use SOH CAH TOA to determine the direction. **PSAYW**

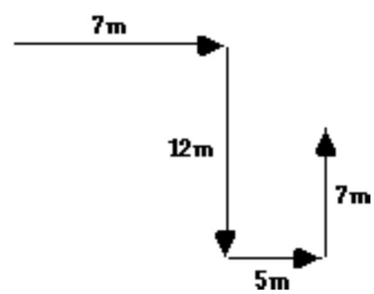




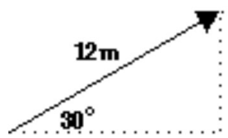


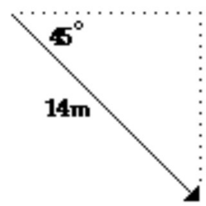
2. Use the Pythagorean Theorem and SOH CAH TOA to determine the magnitude and direction of the following resultants.

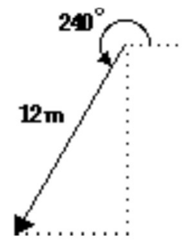




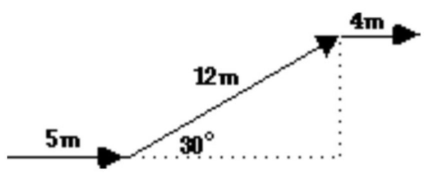
3. A component is the effect of a vector in a given x- or y- direction. A component can be thought of as the projection of a vector onto the nearest x- or y-axis. SOH CAH TOA allows a student to determine a component from the magnitude and direction of a vector. Determine the components of the following vectors.

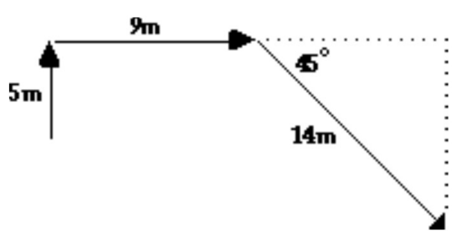






4. Consider the following vector diagrams for the displacement of a hiker. For any *angled* vector, use SOH CAH TOA to determine the components. Then sketch the resultant and determine the magnitude and direction of the resultant.





Vectors and Projectiles **Name:** ______________________________

Vector Representation

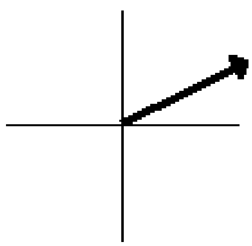
Read from **Lesson 1** of the **Vectors and Motion in Two-Dimensions chapter** at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/vectors/u3l1a.html

MOP Connection: Vectors and Projectiles: sublevel 1

Vector quantities are quantities that have both magnitude and direction. The direction of a vector is often expressed as a counter-clockwise angle of rotation of that vector from due east (i.e., the horizontal). For questions #1-6, indicate the direction of the following vectors.

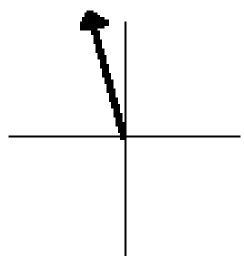
1.



CCW Dir'n: __________

magnitude: ____________

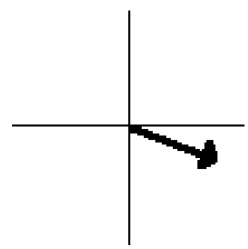
2.



CCW Dir'n: __________

magnitude: ____________

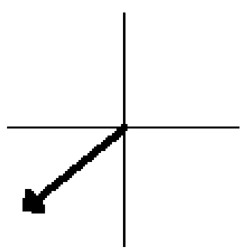
3.



CCW Dir'n: __________

magnitude: ____________

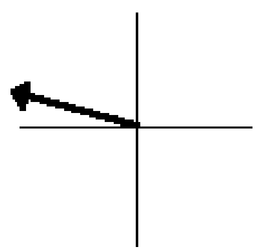
4.



CCW Dir'n: __________

magnitude: ____________

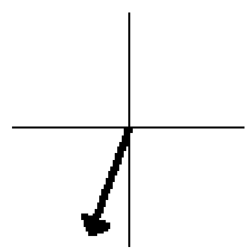
5.



CCW Dir'n: __________

magnitude: ____________

6.



CCW Dir'n: __________

magnitude: ____________

7. The above diagrams are referred to as scaled vector diagrams. In a scaled vector diagram, the magnitude of a vector is represented by its length. A scale is used to convert the length of the arrow to the magnitude of the vector quantity. Determine the magnitude of the above six vectors if given the scale: 1 cm = 10 m/ s.