# Honors Physical Science **Name** ______________________________

# Skills Review and Summer Work, 2021

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 (Mr. 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.

**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. By using the following conversion chart, converting from one unit to another is done simply by moving the decimal point:

**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).

**PART A**

*What type of measurement is indicated by each of the following units? Choices are in the last column.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. | g/mL | ____________ | 4. | g | ____________ | 7. | mg | ____________ | density |
| 2. | s | ____________ | 5. | $cm^3$ | ____________ | 8. | L | ____________ | length |
| 3. | km | ____________ | 6. | mm | ____________ | 9. | $g/cm^3$ | ____________ | mass |
| | | | | | | | | | time |
| | | | | | | | | | volume |

**PART B**

1. Physics usually uses the ***MKS*** system, a variation of SI units. ***MKS*** stands for meter, kilogram, second. These are the most useful choice of units for physics. The equations in physics (and physical science) depend on unit agreement. You must convert to ***MKS*** in most problems to arrive at the correct answer.

| | |
|---|---|
| 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 ($\mu m$) to/from meters (*m*) | Other conversions will be taught as they become necessary. |

What if you don't know the conversion factors? Colleges want students who can find their own information (so do employers). Hint: Google can help with this, and free conversion apps are easy to find, so please take the initiative to find what you need and use it.

*To start, Convert the following metric measurements:*

| | | |
|---|---|---|
| 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) $2.30 \times 10^{4}$ ________________________________

10) $1.76 \times 10^{-3}$ ________________________________

11) $1.901 \times 10^{-7}$ ________________________________

12) $8.65 \times 10^{-1}$ ________________________________

13) $9.11 \times 10^{3}$ ________________________________

14) $5.40 \times 10^{1}$ ________________________________

15) $1.76 \times 10^{0}$ ________________________________

16) $7.4 \times 10^{-5}$ ________________________________

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

a. $8.8\text{x}10^{-8}$ *m* = ________________ *mm*

b. $6.23\text{x}10^{-7}$ *m* = ________________ *nm*

c. $1.5\text{x}10^{11}$ *m* = ________________ *km*

d. $2.5\text{x}10^{-3}$ $m^2$ = ________________ $mm^2$

e. $5.70\text{x}10^{-3}$ *L* = ________________ $cm^3$

**Applications of Dimensional Analysis and Scientific Notation:**

1. Here are some physics equations with numbers in scientific notation already in place. Evaluate these expressions and round the answer to the correct number of 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. $K = \dfrac{1}{2}\left(6.6\times10^{2}\ kg\right)\left(2.11\times10^{4}\ m/s\right)^2 =$ _______________

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

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

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

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

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

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

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

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

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

i. $pV = nRT$ $\quad , T =$ ______________

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

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

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

(Hint: example f above is solved using a quadratic equation—you can skip it for now if you aren't familiar with how, and we'll go over it in class if needed)

**Part 3: 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.

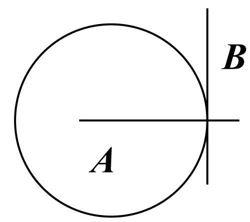
a. Line ***B*** touches the circle at a single point. Line ***A*** extends through the center of the circle.

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

________________

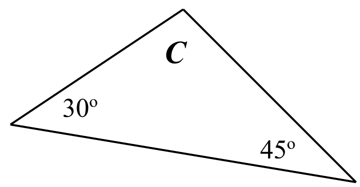
ii. How large is the angle between lines ***A*** and ***B***?

________________



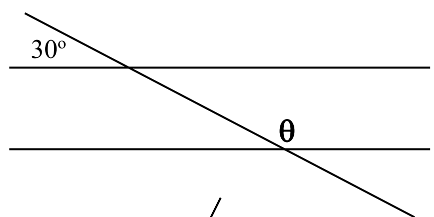

b. What is angle ***C***?

________________



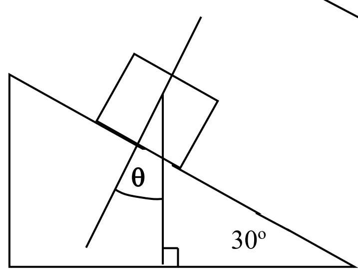

c. What is angle θ ?

________________




d. How large is *θ*?

________________




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

i. What is the circumference in meters?

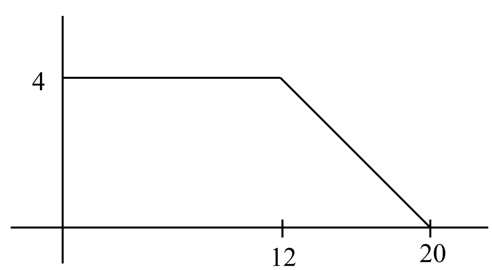
________________

ii. What is its area in square meters?

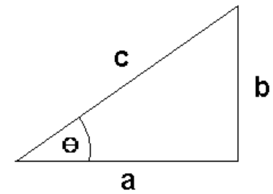
________________

f. What is the area under the curve at the right?

________________



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. ***Your calculator must be in degree mode.*** Round your answers to 2 sig figs and include units.




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

________________

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

________________

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

________________

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

________________

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

________________

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

________________

**Part 4: Vectors:** Most of the quantities in physics are vectors. This makes proficiency in vectors extremely important.

Open the tutorial on vectors at the website: http://www.physicsclassroom.com/Class/vectors/
Read the tutorials and complete the worksheets on the following pages:

## *Lesson 1: Vectors - Fundamentals and Operations*

a. Vectors and Direction
b. Vector Addition
c. Resultants
d. Vector Components
e. Vector Resolution
f. Component Method of Vector Addition
g. Relative Velocity and Riverboat Problems
h. Independence of Perpendicular Components of Motion

The remaining exercises are based on the Lesson 1: Vectors links provided above:

## Vector Representation

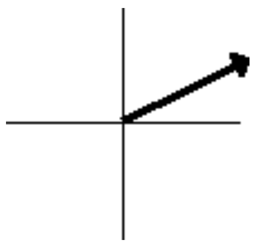
Read from **Lesson 1** of the **Vectors and Motion in Two-Dimensions chapter** at **The Physics Classroom**:

**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.

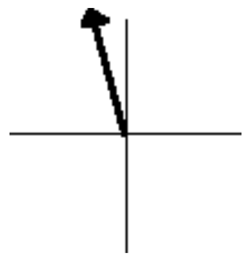
1.



CCW Dir'n: __________

magnitude: ___________

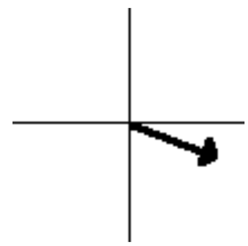
2.



CCW Dir'n: __________

magnitude: ___________

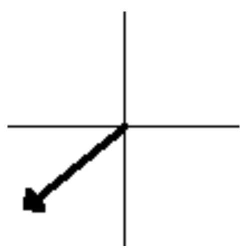
3.



CCW Dir'n: __________

magnitude: ___________

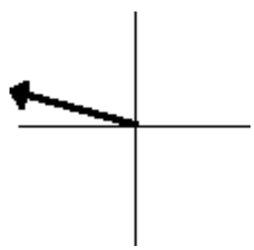
4.



CCW Dir'n: __________

magnitude: ___________

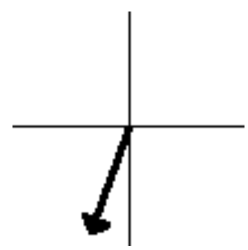
5.



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.

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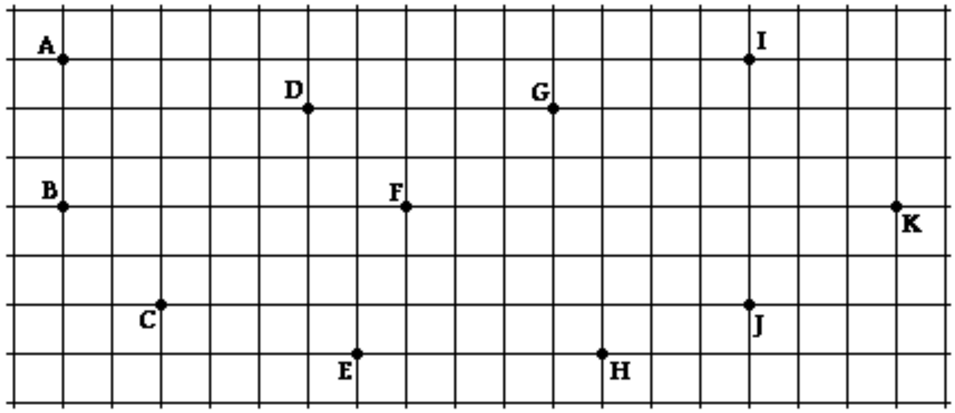
**Vectors and Projectiles**

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°. |

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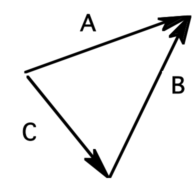
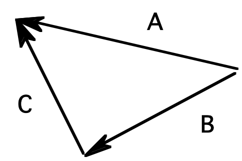
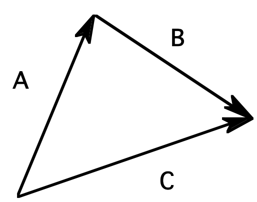
## Addition of Vectors

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

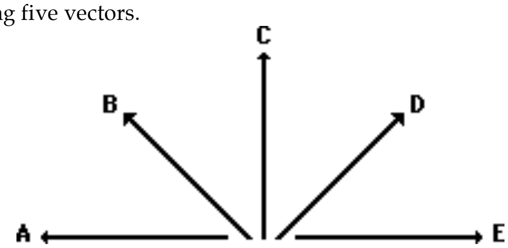
**http://www.physicsclassroom.com/Class/vectors/u3l1b.html**
**http://www.physicsclassroom.com/Class/vectors/u3l1c.html**

**MOP Connection:** Vectors and Projectiles: sublevels 2, 3 and 4

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: _______<br>Vector Eq'n: ______________________________<br>Dir'n of R: ______________________________ |
|  | Resultant is: _______<br>Vector Eq'n: ______________________________<br>Dir'n of R: ______________________________ |
|  | Resultant is: _______<br>Vector Eq'n: ______________________________<br>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**

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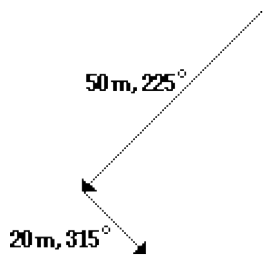
**Vectors and Projectiles**

**Math Skill:**

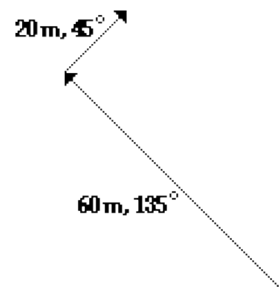
Vectors that make right angles to each other can be added together using Pythagorean theorem. Use Pythagorean theorem to solve the following problems.

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: |

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## 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**

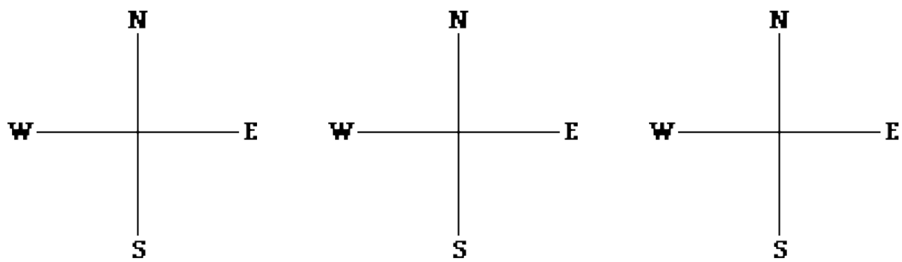
**MOP Connection:** Vectors and Projectiles: sublevels 3 and 5

**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.

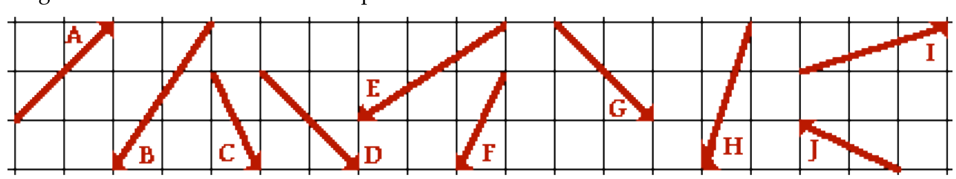
**45 km, 300°** **10 km, 265°** **200 mi, 150°**




Components: **E W N S** Components: **E W N S** Components: **E W N S**

Greatest magnitude? ______ Greatest magnitude? ______ 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 | | |

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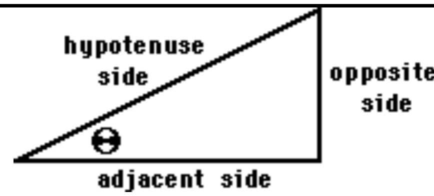
**Vectors and Projectiles**

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

**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

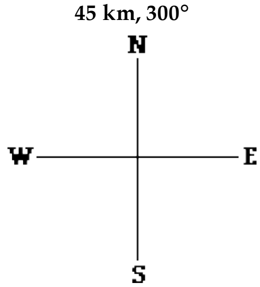
**SOH CAH TOA**




**SOH** --> **S**in $\Theta = \frac{\text{Opposite}}{\text{Hypoteneuse}}$ **CAH** --> **C**os $\Theta = \frac{\text{Adjacent}}{\text{Hypoteneuse}}$ **TOA** --> **T**an $\Theta = \frac{\text{Opposite}}{\text{Adjacent}}$

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.

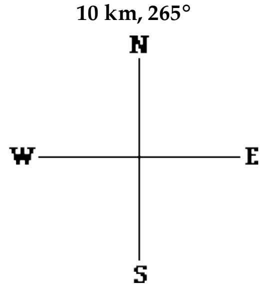
**45 km, 300°**




E-W Component:

N-S Component:

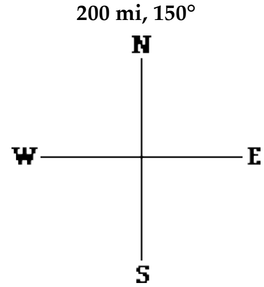
**10 km, 265°**




E-W Component:

N-S Component:

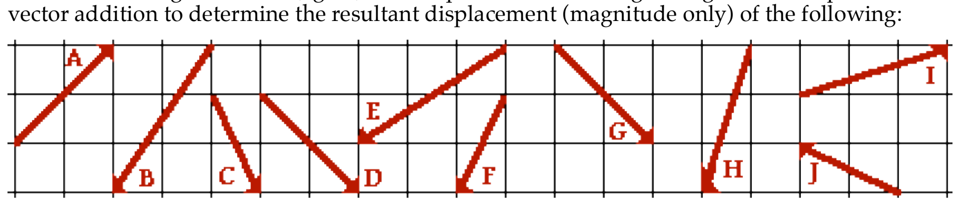
**200 mi, 150°**




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: ______________

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## 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**

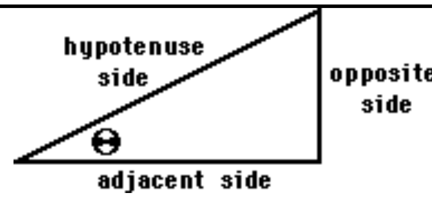
**MOP Connection:** Vectors and Projectiles: sublevels 3 and 4

**TIP**

**Trigonometry Review**

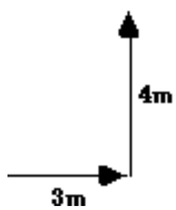
Trigonometric functions are mathematical functions that relate the length of the sides of a right triangle to the angles of the triangle. The meaning of the functions can be easily remembered by the mnemonic

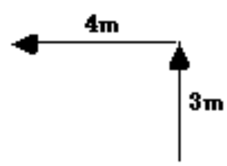
**SOH CAH TOA**

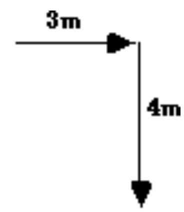



**SOH** --> **S**in $\Theta = \frac{\mathbf{O}\text{pposite}}{\mathbf{H}\text{ypoteneuse}}$ **CAH** --> **C**os $\Theta = \frac{\mathbf{A}\text{djacent}}{\mathbf{H}\text{ypoteneuse}}$ **TOA** --> **T**an $\Theta = \frac{\mathbf{O}\text{pposite}}{\mathbf{A}\text{djacent}}$

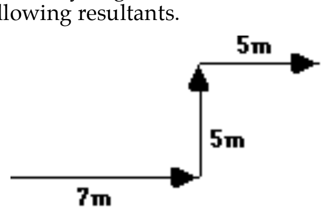
1. For the following vector addition diagrams, use Pythagorean Theorem to determine the magnitude of the resultant. Use SOH CAH TOA to determine the direction. **PSAYW**

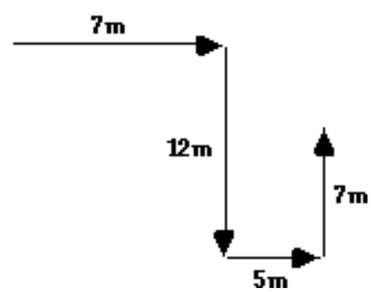


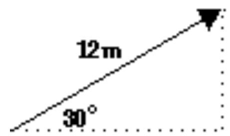



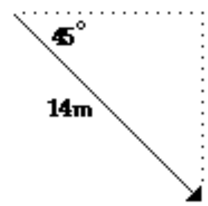

2. Use the Pythagorean Theorem and SOH CAH TOA to determine the magnitude and direction of the following resultants.

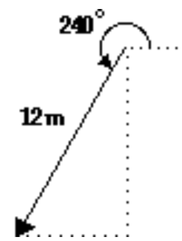


3. A component is the effect of a vector in a given x- or y- direction. A component can be thought of as the projection of a vector onto the nearest x- or y-axis. SOH CAH TOA allows a student to determine a component from the magnitude and direction of a vector. Determine the components of the following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