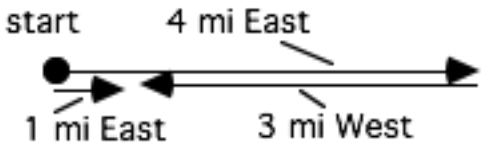
Purpose : You will learn how to use two different methods to add vectors.
Materials: Scientific calculator, pencil, unlined paper, protractor, ruler.
Discussion: A vector has both magnitude and direction. You cannot add vectors the same way that you add scalars(quantities without direction). Two plus two is not always four.
For example, here is an example of a simple vector problem. If you drive 4 miles east and then 3 miles west, although you have driven a total of 7 miles, you are only 1 mile from where you started. Your **displacement**, the distance and direction from the starting position, is 1 mi East. This was an example of one-dimensional addition.



Vector problems are not always this easy. In order to add vectors in two dimensions, we cannot rely only on plus and minus for direction.

Here is a sample problem that shows you how to use two different methods to add two-dimensional vectors.
Problem: If you drive 3 miles at bearing 30 degrees and then 4 miles at bearing 60 degrees, what is your displacement?

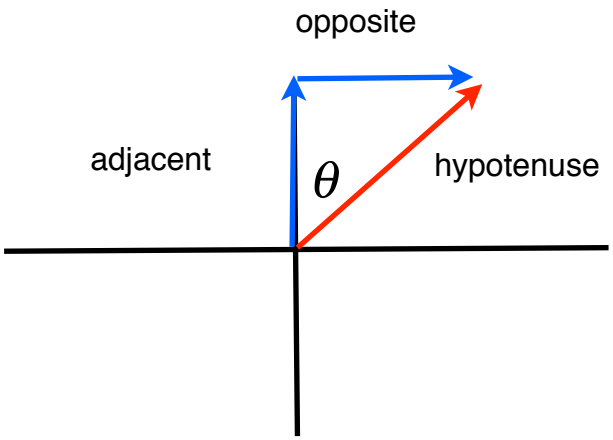
Please make a note of the **direction reference system** that I am using. When the words *bearing, at or North, South, East, West* are used, always count the direction in degrees **clockwise from North**. North is 0 degrees, East is 90 degrees, South is 180 degrees, and West is 270 degrees.

Method 1 - Vector addition -trigonometric solution. We will be using trig. rules for solving right triangles. We always break the vectors up into components that are at right angles to each other..

<u>You must have the following rules memorized before coming to lab.</u>

$$Sin\ \theta \equiv \frac{opposite}{hypotenuse} \qquad \text{Cosine } \theta \equiv \frac{adjacent}{hypotenuse} \qquad Tangent\ \theta \equiv \frac{opposite}{adjacent}$$

Pythagorean theorem: $hyp^2 = \text{opp}^2 + \text{adj}^2$ *Therefore*, $\text{hyp} = \sqrt{\text{opp}^2 + \text{adj}^2}$



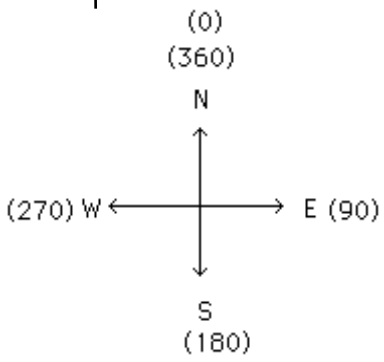
Name_____

Lab 2 preparation: Hand this part in before the lab starts.
Solve the following practice problem at home before coming to the lab. Follow along with paper, pencil and calculator. Let's ***add 3 miles bearing 30 degrees to 4 miles at 60 degrees***. First we will break each vector into its right angle components and enter them into a table.

Baby Step 1- Make a N-S, E-W Table.
In the left column, north components will be positive and south components will be negative. In the right column, east components will be positive and west components will be negative.

North - South	East - West

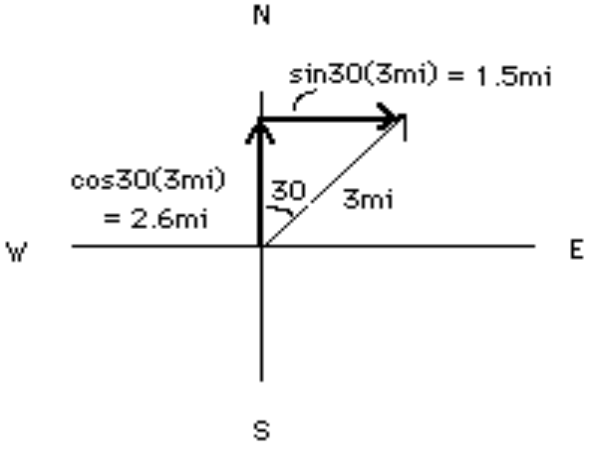
Baby Step 2- Draw a North, South, East, West grid. Please remember that bearing is measured clockwise from north, in degrees.



Baby Step 3 -Sketch the 1st vector of the problem and draw its right angle components. Remember that each component has a direction and that they combine head to tail terminating at the tip of the 1st vector. The first vector of the problem is 3 miles at 30 degrees.

Use the sine function to determine the opposite side.

Use the cosine function to determine the adjacent side.



Baby Step-4-Place the values of the two components into the table. The 1.5 mi component is pointing East, and the 2.6 mi component is pointing North. At this point, make sure that you know why I used Sine to find the component that was opposite the angle, and cosine to find the component that was adjacent to the angle. Make sure that the units of angular measure on you calculator are **degrees**, not radians.

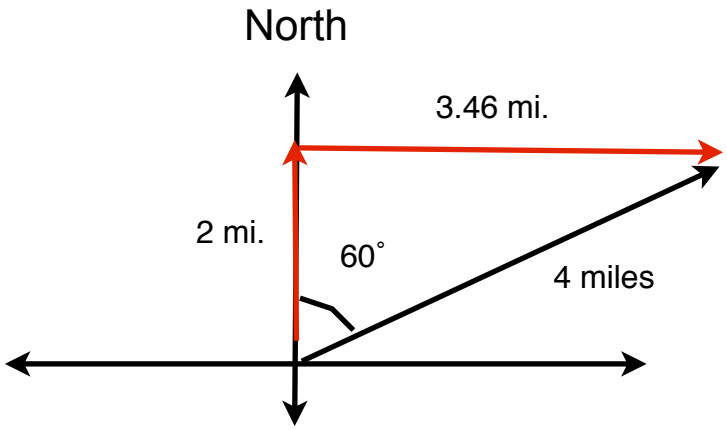
(miles)

North - South	East - West
2.6	1.5

Note that 'North' and 'East' should be entered into the chart as positive and any 'South' and 'West' should be entered as negative.

Baby Step 5-Draw a **new** North-South, East-West Grid and sketch the next vector. Then break the vector up into its right angle components. Using the trigonometric functions of sine and cosine, determine its right angle components.

The second vector is 4 miles at 60 degrees. I have determined the value of the north and east components. Please verify this using the trig. functions and your calculator.



Use the sin definition to determine the length of the side opposite the 60˚ angle and cosine function to determine the side adjacent to the 60˚ angle.

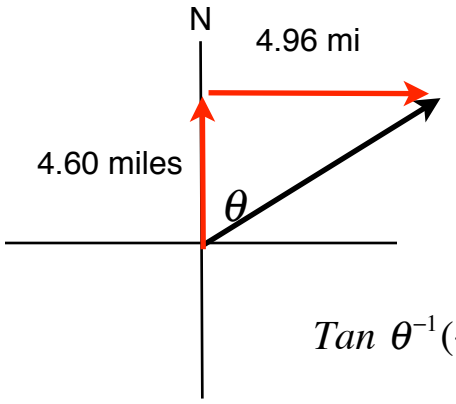
Show your work here.

Baby Step 6- Place the components in your table and add them up.

(miles)

North - South	East - West
2.6	1.5
2.0	3.46
4.6	4.96

Baby Step 7- Draw one last grid and sketch in the sum of the N-S and E-W components from your chart. Use the tangent function to find the unknown angle θ and the Pythagorean theorem to find the resultant.



$$hyp = \sqrt{4.96^2 + 4.6^2} = 6.76 \text{ miles}$$

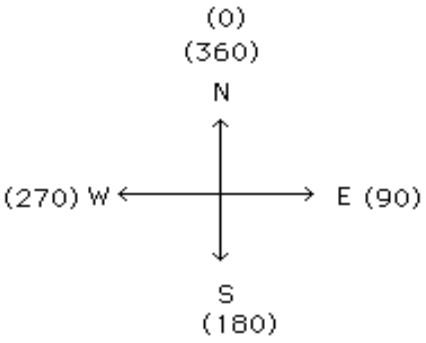
$$Tan\ \theta^{-1}(\frac{4.96}{4.6}) = 47.1^\circ$$

Answer 6.76 miles at 47.1 degrees

Remember that you should be following along on paper and with your calculator. Check to see if your answers agree with mine. Hand this work in before the lab begins.

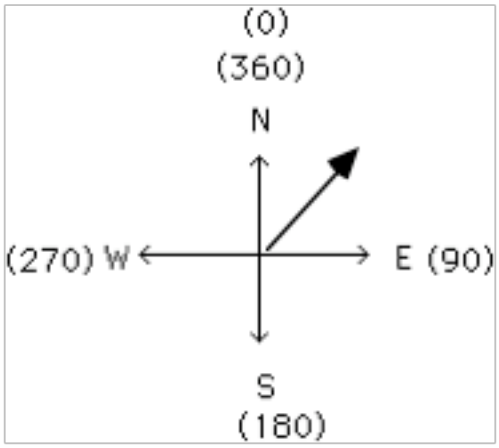
Optional Method 2: Extra credit + 1, Graphical solution-**Don't attempt method 2 until you completely understand method 1**. Follow along with paper, pencil a ruler and protractor. We will solve the same using another method.
Problem: Add 3 miles bearing 30 degrees to 4 miles at 60 degrees.

Baby Step 1- Draw and label a grid with compass coordinates N, S, E, W.

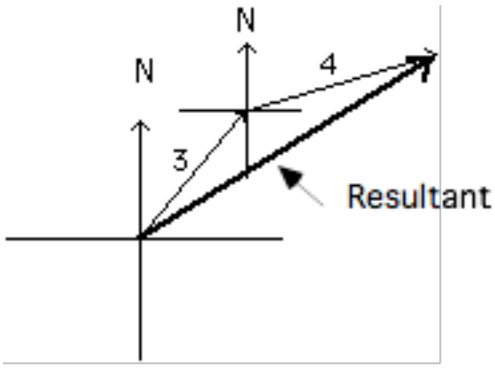


Method 2, **Baby step 2**:

Starting at the origin, draw one of the vectors (starting at the origin) to scale using a ruler(example 2 cm =1 mi) and in the correct direction using a protractor. Let's first draw the 3 miles at 30 degree vector.



Method 2, **Baby step 3**- Draw another North, South, East, West, grid at the tip of the vector and then draw the other vector to scale, starting at the origin of the second grid.



Baby step 4- Draw an arrow from the origin of the first vector to the tip of the last vector. This is the answer and is known as the **RESULTANT** - it is the sum of the other vectors. To finish the solution, use your ruler to obtain the magnitude of the answer and use your protractor to determine its direction. Write your answer here-Answer_____

Compare the magnitude of the answer from the graphing method with the answer from the trig. method. If you have been careful, the magnitudes should agree to within 4%.

In order to calculate the percent error, use the following rule:

$$\%\ \text{error} = \frac{\text{the positive differnce between your answer and the accepted answer}}{\text{accepted answer}}(100\%)$$

Use the trigonometric solution as the accepted answer.

Name_____/Section_____

LAB 2: Vector addition

Solve the following problems using the trig. method-Method 1. Once you have completed the method 1 solutions, you can do method 2 for extra credit. Hand in all the work that you do in solving these problems.

(a) 5 mi at 30 deg + 2 mi at 200 deg

(b) 420 mi at 220 deg + 300 mi at 270 deg.

(c) 4.2 mi/hr at 80 deg + 8.2 mi/ hr at 140 deg.-Solved in the 'Vector Addition' lecture.

(d) 10 Newtons at 120 deg. + 8 Newtons at 80 deg. + 12 Newtons at 300 deg.

RESULTANT: Enter the magnitude and direction of the resultant found using the the trig. method in the chart below. If you do **method 2** for extra credit, calculate the % error by comparing just the magnitudes. They should be within 4% of each other.

Problem	**Method 1** trig. solution	**Method 2** graphical solution	**% error=**
a			
b			
c			
d			