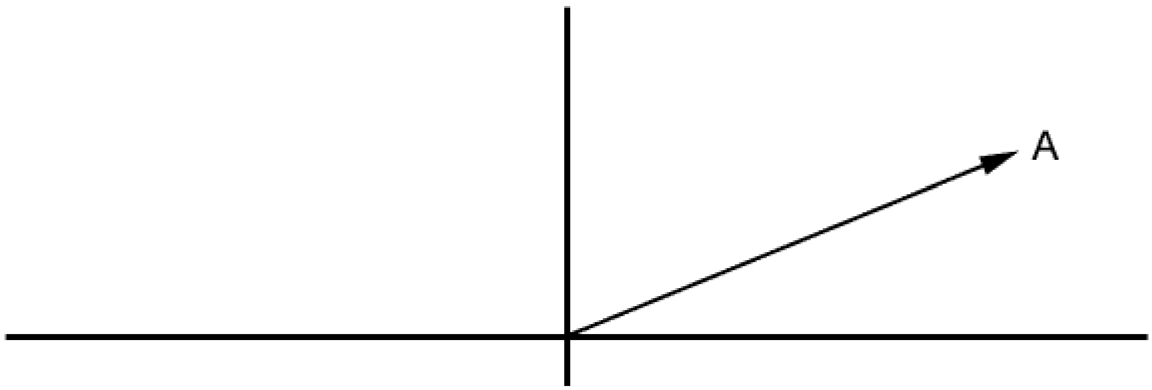
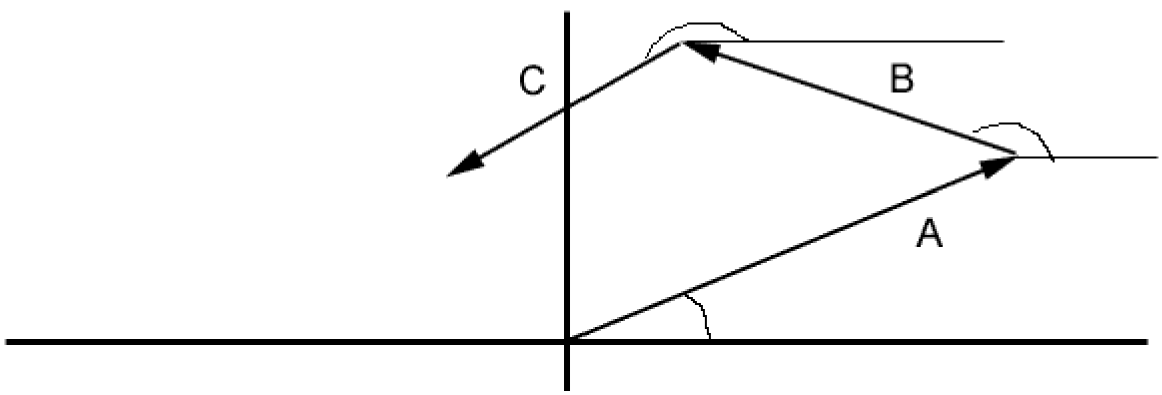
COMPOSITION OF CONCURRENT FORCES

INTRODUCTION: This lab takes the mathematical concept of a vector and makes it tangible. Here we will explore two ways of finding the resultant of 2 or more vectors. These include the graphical method and the component method. By concurrent forces we mean that all the vectors in the system converge at a single point.

GRAPHICAL METHOD: Any vector can be represented by a line with an arrow at the end. The length of the line represents the magnitude, perhaps a velocity or force. One chooses a convenient scale (for instance, 1gram = 1cm) and actually draws the vector, using a protractor to determine the direction (angle). See picture below:



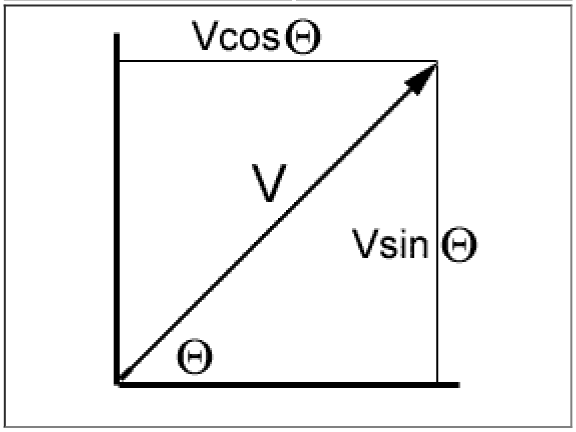
To add three vectors, **A**, **B**, and **C**, by the head-to-tail method, draw **A** first, then at the head of **A** draw **B**. Be sure to measure the angle of **B** from a line parallel to the x axis! Don't measure the angle from **A**. Finally, draw vector **C** starting from the head of **B**, again using a line parallel to the x axis for direction as you did with **B**. The resultant is found by drawing a line from the origin to the head of **C** and measuring the direction with a protractor and the magnitude with a ruler. See picture below:



The graphical methods are not as accurate as the calculation methods, but pictorial methods often have advantages over numerical methods.

COMPONENT METHOD: Any vector can be broken down into components. A component is essentially the shadow it makes on the coordinate axes. For a Cartesian rectangular coordinate system the components for any vector **V** of magnitude V at angle Theta are:

$V_x = V\cos\Theta$	$V_y = V\sin\Theta$



If all angles are measured from the positive x axis (0^{o} or east), the sign of the component is included by the calculator. This is convenient in the addition (or subtraction if you change the sign) of vectors by the component method. To add two or more vectors you first add the like components of all the vectors:

ΣV_x	ΣV_y

Then the magnitude of the resultant R is found by:

$$R = \sqrt{(\Sigma V_x)^2 + (\Sigma V_y)^2}$$

and its direction is found by:

$$ATAN\left(\frac{\Sigma V_y}{\Sigma V_x}\right) = \Theta$$

This method works for any number of vectors.

In order to find the negative of vector **R** graphically draw the vector 180^{o} from the original vector while keeping the same length. Finally, to find the negative of a vector mathematically one will add 180^{o} to the angle of **R** and preserve its magnitude.

TASK:

To determine graphically and mathematically the resultant of several vectors and compare both answers.

APPARATUS:

Metric Ruler
Protractor
Graph Paper (you have to bring some for this lab).This is not your regular notebook paper.

PROCEDURE:

Given:

- Vector **A**: 1.96 N @ 25^o
- Vector **B**: 0.98 N @ 70^o
- Vector **C**: 1.47 N @ 150^o

1. Graphically construct **R** = **A** + **B** - **C** to scale on a piece of paper using the head to tail method. That is, draw **A** to scale. Choose a scale of **3.5 cm = 1.0 N**. Then, using the head to tail method add **B** to **A**(also drawn to scale). Then add **-C** to **B**. Finally, draw a vector from the tail of **A** to the head of **C** and call it **R** for Resultant. Measure the length of **R** with a ruler in cm, and convert it to Newtons. Also, measure the angle in degrees that **R** makes with the positive x axis using a protractor. Write down these numbers(magnitude of **R** in N and the angle it makes with the positive x axis) on the diagram and box them in clearly.
2. Using the component method calculate **R** above. That is, calculate its magnitude(in N), and the angle in degrees that **R** makes with the positive x axis. Clearly write these numbers and box in the result.
3. Compare these results for the magnitude and angle of **R** with those in Step #2 by calculating a percent difference.
4. Using the above results, find the value of a vector **E** (magnitude and direction), such that: **A** + **B** - **C** + **E** = 0. Hint: use the average values of **R** and the angle from parts 1 and 2. This vector will represent the necessary force to maintain the system in equilibrium. That is, the sum of the forces in the system will be equal to zero.