Vector Force Table

Objective: The objective of this experiment is to study vectors and compare experimental results with graphical and analytical calculations by finding a resultant force that balances out the given force so that the system will be in equilibrium.

Apparatus: Force table, weight holders, sets of masses, rulers, protractors, spirit levels.

Theory: Vectors **A** and **B** can be added graphically by drawing them to scale and aligning them head to tail. The vector that connects the tail of **A** to the head of **B** is the resultant vector **R**. Vector addition is both associative and commutative.

The components (A_x and A_y) of a vector **A** can be calculated by projecting the length of **A** onto the coordinate axes as shown in figure 1. The components can be obtained by using the following equations:

$$A_x = |A| \cos \theta_A \qquad A_y = |A| \sin \theta_A \qquad (1)$$

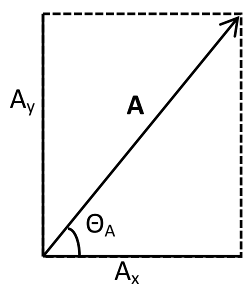


Figure 1.

The sign of a component gives its direction along the x or y axis. Conversely, from the components, the magnitude |**A**| and direction θ of the vector can be calculated using the following:

$$|\mathbf{A}| = \sqrt{A_x^2 + A_y^2} \qquad \theta = \tan^{-1}(A_y/A_x) \qquad (2)$$

In order to add vectors analytically, they must be in component form. The components of a vector sum of two vectors **A** and **B** yields the components of a new vector, called a resultant vector and will be denoted by **R**. The components of **R** can be calculated by:

$$R_x = A_x + B_x \qquad R_y = A_y + B_y \qquad (3)$$

In this experiment, each group will find the direction and magnitude of a force **C** that balances out the forces of **A** and **B** so that the system will be in equilibrium. In order to for the system to be in equilibrium, the following must hold:

$$\mathbf{A} + \mathbf{B} = -\mathbf{C} \qquad \mathbf{A} + \mathbf{B} + \mathbf{C} = 0 \qquad (4)$$

Procedure: Place the force table on a flat surface. Using the spirit level, make sure the force table is level. Cut three pieces of string ~21 inches long. Tie a loop at the end of each piece of string, and attach the other end of the string to the ring. Place the ring in the center of the force table so that it encircles the pin. Put the strings over the pulleys attached to the force table. Make sure that the pulleys are fixed at the same height around the table.

Get three mass holders. For vector **A**, add mass to one mass holder until the entire setup (mass holder and added mass) is ~27 g. Place this mass on the end of one of the strings looped over a pulley and set the pulley at an angle of 63°. For vector **B**, to the second mass holder, add mass until the entire setup is ~41 g. Place this mass on the end of one of the available strings looped over a pulley and set the pulley at an angle of 154°.

For vector **C** (the resultant), attach the last mass holder to the last string looped over a pulley. Add mass to the system and adjust the angle until the system is in equilibrium. When the system is in equilibrium, the ring with the attached strings will be parallel to and suspended above the ring painted on the force table, and the pin can be removed. Once equilibrium is reached, determine the entire mass for the setup of vector **C**.

Record the values for mass and angle for vectors **A**, **B**, and **C** in Table 1. Record the values for mass and angle of vectors **A** and **B** in Table 2. Use the formulas given to calculate the mass and x and y- components of vectors **A** and **B**, and calculate the mass, force, components, and angle for vector **C**.

Draw the vectors **A**, **B**, and **C** and their corresponding components to scale in the space provided. Also, draw the complete system of vectors **A**, **B**, and **C** together in the space provided. Be sure to label the vectors, forces and angles.

Compare the experimental results for mass and angle measure of vector **C** with the analytical calculations. Determine the percentage error.

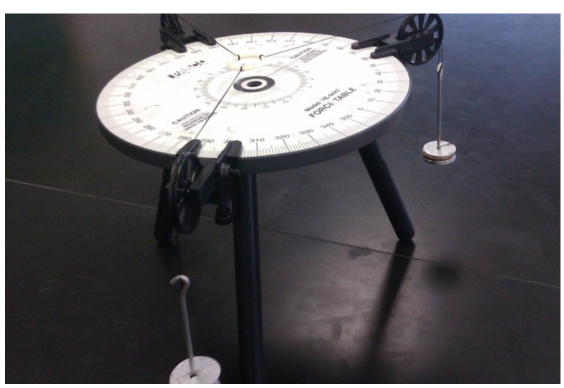


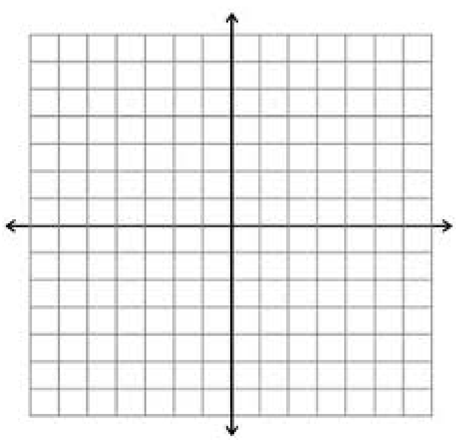
Figure 2.

	A	B	C
Mass (g)			
Θ (°)			

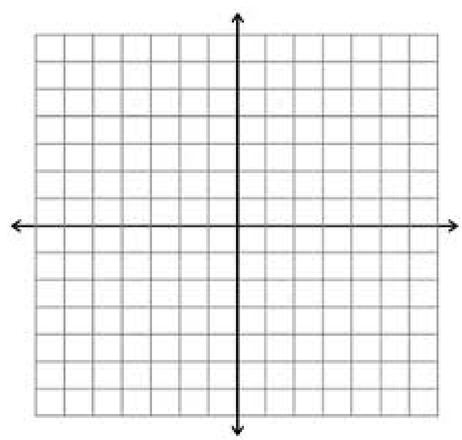
Table 1. Experimental Results

	A	B	C
Mass (g)			
Force (N)			
x-component (N)			
y-component (N)			
Θ (°)			

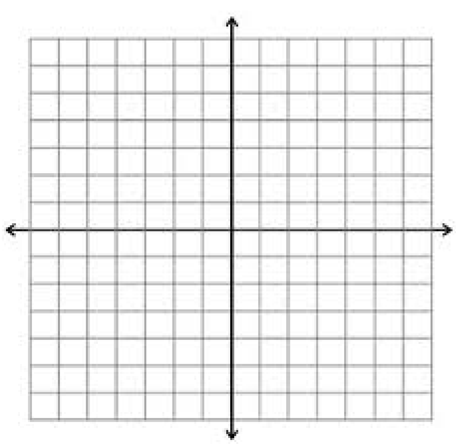
Table 2. Analytical Calculations



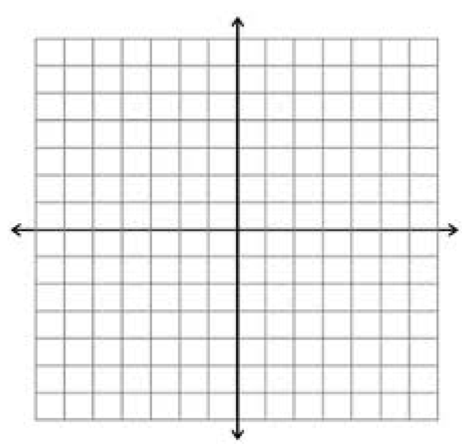
Vector A



Vector B



Vector C



Vectors A, B, and C

Graphical Sketches.