PHSX 101L **Experiment 3** **Name:**____________________

Title: Forces as Vectors

Object: To study how simultaneous forces combine together to produce a resultant force.

Introduction: A basic concept in the study of physics is that forces can be represented theoretically by vectors. This means that when several forces act simultaneously on the same object, they combine together into one resultant force. This resultant force can be calculated theoretically using the rules of vector addition. The following are two theoretical methods for combining vectors:

1. By diagram (graphically): Several vectors representing concurrent forces can be added by diagramming the vectors head-to-tail using rulers and protractors to measure the magnitude and direction of each vector. The resultant vector is found by drawing an arrow from the tail of the first vector in the series to the head of the last.

2. By component (numerically): The resultant of several concurrent vectors can also be found by breaking each vector (of magnitude r and direction θ) up into its x- and y-components.

$$x = r\cos\theta \qquad y = r\sin\theta \tag{1}$$

Corresponding components of the several forces are then added together separately to obtain the x- and y-components of the resultant. The magnitude and direction of this resultant vector are given by:

$$r = \sqrt{x^2 + y^2} \qquad \theta = \tan^{-1}\left(\frac{y}{x}\right) \tag{2}$$

Procedure: Using a force table, set up the forces as described in the following list. Determine an additional force so as to balance the resultant of the given forces. This balancing force, which you will find by trial and error, is the *reverse* of the resultant force you are looking for. There are only two forces to be added in trial 1; three in trial 2. Use equation 1 to get the x- and y-components for each vector, and after summing them use equation 2 to find the magnitude and direction.

Apparatus: Draw the force table.

Trial 1		(x-comp., y-comp.)
$\boldsymbol{A}$ = 135 g at 35°	→	(,)
$\boldsymbol{B}$ = 150 g at 110°	→	(,)
sum =	←	(,)

Trial 2		
$\boldsymbol{A}$ = 110 g at 20°	→	(,)
$\boldsymbol{B}$ = 100 g at -75°	→	(,)
$\boldsymbol{C}$ = 150 g at 120°	→	(,)
sum =	←	(,)

Theoretical Results: As in most scientific work, the results of the experiment (in this case the resultant force obtained from the force table) are to be compared with theoretical predictions. The theory of vectors described above is to be applied to the given forces, and a resultant is predicted.

1. Record the magnitude and direction of each resultant force predicted by the *diagram* method.

   Trial 1: $r_1 =$ ______________ $\theta_1 =$ ______________

   Trial 2: $r_2 =$ ______________ $\theta_2 =$ ______________

2. Record the magnitude and direction of each resultant force predicted by the *component* method.

   Trial 1: $r_1 =$ ______________ $\theta_1 =$ ______________

   Trial 2: $r_2 =$ ______________ $\theta_2 =$ ______________

Experimental Results: What was the result (vector sum) of each trial as measured experimentally? (Remember, the resultant force is the opposite or negative of the balancing force.)

Trial 1: $r_1 =$ ______________ $\theta_1 =$ ______________

Trial 2: $r_2 =$ ______________ $\theta_2 =$ ______________

Analysis: Find the percent difference between the experimental vector *magnitudes* obtained on the force table and those obtained by each theoretical method for each trial.

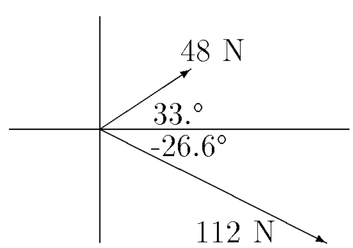
	Diagram	Component
Trial 1:	______________	______________
Trial 2:	______________	______________

Question: Find the net force (both magnitude and direction) for the two forces shown below:

Resultant:

magnitude (r) = ______________

direction (θ) = ______________



Conclusions: