PHYSICS 130 LABORATORY

EXPERIMENT 2

VECTORS USING THE FORCE TABLE

NAME___________________ DATE _________SECTION ___________

PARTNERS ___________________ ____________________ _______________

OBJECTIVE

In this experiment you will investigate the general properties of vectors noting their resolution into components and their additive properties. The type of vector which will be used to illustrate these properties will be the vector representing forces.

EQUIPMENT

Force table
Four clamp-mounted pulleys Ring with four strings attached Four 50-g mass hangers
Set of masses

DISCUSSION

If a number of nonparallel forces are acting at the same point on a body, it can be shown that they may be replaced by a single force which will produce the same effect on the body. Such a force is called the resultant of the original forces. A single force which will hold the system of concurrent forces (forces acting through a common point) in equilibrium is called the equilibrant of the system. Although you will be finding the equilibrant of the system, in effect you may also determine the resultant, since the equilibrant is equal in magnitude to the resultant, but oppositely directed.

The part of a force effective in some particular direction is called a component of the force. Normally, we use two components at right angles to each other. The process of finding components of forces in specified directions is called the resolution of forces.

NOTE: In this experiment we will refer to forces measure in grams. We will not bother to multiply each mass by the acceleration of gravity since that factor will cancel out of each term when forces balance. Although this is not strictly correct, it is convenient and common to do so.

PRE-LAB EXERCISE

1. Complete the following table by finding the x-component and y-component for each force vector.

Magnitude	Direction	x-component	y-component
125 g	45º		
90 g	120º		
160 g	330º		

2. Find the vector sum (in rectangular form) of the three forces in Step 1 by adding the x-components and adding the y-components.

x-component of vector sum ___________________________

y-component of vector sum ___________________________

3. Convert the vector sum from rectangular to polar form

Magnitude ______________________ Direction _______________________

PROCEDURE and ANALYSIS OF DATA

I. EQUILIBRANT FORCE

1. Put 300 grams (including the mass hanger) at the 0° position and 500 grams (including the mass hanger) at the 900 position. By trial and error find a mass (including the mass hanger) and position for a third force that will balance the first two. This is called the equilibrant force.

To obtain an estimate of the precision of your measurements, find out how much mass you can add or subtract to the third mass hanger without changing the position of the center ring. Also, find out how much you can change the angular position of the third mass hanger without changing the position of the center ring.

Uncertainty in mass _______________________ Uncertainty in position ________________________

Record the weight and angular position (with their experimental uncertainties and units) for the equilibrant force.

Mass of equilibrant force___________________________ Position_________________________

II. RESULTANT FORCE

2. Calculate, showing your work in the space provided, the resultant of the two forces given in step one.

Calculations:

Magnitude ______________________________ Direction ________________

Compare the resultant force in this step with the equilibrant force found in Step 1 by finding the percent difference. Are the results within the experimental uncertainties found in step 1?

III. COMPONENTS OF A FORCE

3. Arrange identical masses of 200 g at positions of 40° and 220°. These masses should balance. By trial and error find amounts of mass that can be hung at 0° and 90° to replace the mass at 40°. Determine and record uncertainties with the values of the masses.

Mass at 0°____________________________ Mass at 90°___________________________

4. Calculate the components of the vector with a magnitude of200 g and direction of 40°.

Calculations:

x-component .___________________ y-component ____________________

How do these components compare with the experimental result from Step 4? (Are they within the experimental uncertainties?)

IV. EQUILIBRIUM OF FOUR FORCES

5. Place a mass of 200 g (all masses should include mass hangers) at 0°. Place masses of 70 g, 100 g, and 80 g counterclockwise around the table from the 200 g mass. Adjust the positions of the other three masses so that the *four* forces balance. To determine whether you really have a good balance, nudge the center ring gently with your finger from different directions and see if the ring returns to its position over the center hole. Record the angles in the table below.

Mass	Angle	x-component	y-component
200 g	0º		
70 g			
100 g			
80 g			
	Totals		

6. Calculate the x-components and y-components of the *four* masses, and enter them in the table in Step 5. Add the *four* x-components and y-components. The totals should not differ from zero by more than the experimental uncertainties of your earlier measurements.

7. You may have had difficulty finding a proper balance for the four masses by trial and error. Now, let's be more systematic in the solution of a different problem. Suppose we want to find a single force that will balance the following three forces:

   A = 200 g at 0°   B = 110 g at 80°   C = 250 g at 135°

   To do this, find the sum of the x and y -components of the three vectors and then calculate their resultant. Show your calculations in the space provided and record your results.

   x-component of (A + B + C) = ____________________________________

   y-component nf(A + B + C) = ____________________________________

   Magnitude of (A + B + C) = ____________________________________

   Direction of (A + B + C) = ____________________________________

Suppose we let D represent the equilibrant force which balances forces A, **B,** and C. Then

A + B + C + D = 0 *or* D = **-** (A + B + C)

The equilibrant force we want is the negative of the resultant of the forces A, B**,** and C. To find the negative of a vector you leave the magnitude the same and simply point the vector in the exact opposite direction.

Find and record the magnitude and direction for vector D.

Magnitude of D ______________________________

Direction of D = _____________________________

8. Check the result of Step 7 by hanging the indicated masses from the strings. If your calculated mass is correct, the ring should stay in the middle when you remove the pin. Don't forget that the mass of the mass hanger should be included in the given masses. Round off the calculated masses to the nearest 5 g when checking your results on the force table? Comment on your results.

9. Repeat Step 7 and Step 8 for the following set of force vectors. Write in the magnitude and direction of the fourth force vector which balances the other three. The force table will tell you whether *or* not your calculations are correct. Your answer for the sum should be a <u>calculated</u> answer which is checked on the force table.

A = 300g at 0° Magnitudeof(A+B+C) __________________________________

B = 100 g at 60º Direction of (A + B + C) ________________________________

C = 250 g at 135° Magnitude of D (from force table) ____________________

Direction of D (from force table) _____________________

Calculations: