VECTOR ADDITION

Purpose

To work with vector addition of three vectors.

Apparatus

Graph paper, force tables, weights, protractors.

Theory

Even though this experiment deals with forces, the methods can be used for any vectors. Refer to your textbook for the discussion of vector addition by resolution of vectors into components and by graphical methods. **For all parts, you are to determine the vector sum of the three given forces**.

For the experimental part of this lab, you determine the fourth force acting on an object (the ring on the force table) that will balance the given three so that the net force is zero. With the net force equal to zero, the object will be in equilibrium and if initially at rest will remain at rest. This fourth, balancing force will then have the same magnitude as the sum of the first three and will be in the **opposite** direction as the sum of the first three.

Although forces should be expressed in dynes or newtons (or pounds), for this experiment you can use forces in gram-weights (gram-wt) to save work in the computations. Thus if you have a 150 gram mass hanging from one side of the force table, you can consider the force exerted by this on the center ring to be 150 gram-wt, rather than converting to dynes or newtons. In your scale drawings, be sure to convert your lengths to gram-wt, too, and label your drawing with gram-wt, rather than length units such as cm.

Procedure

1. Set up the given forces on the force table and determine experimentally the force necessary to balance (sum of all forces equal zero) them. Make an estimate of the uncertainty in the magnitude of the balancing force. For example, how much mass can you add and subtract without affecting the balance? Express this uncertainty both as absolute and as percentage uncertainty. Also, determine the absolute uncertainty of your angle measurement. (Do **not** do a percent uncertainty for the angle.) Since this balancing force has the same magnitude as the resultant (or sum) of the three given forces but is applied in the opposite (180°) direction from the resultant force, then the sum of the three (the resultant force) has the same magnitude and the opposite direction as the balancing force. What then is the magnitude and direction of the resultant (sum) of the three given forces?

2. For the three forces given to you, calculate the direction and magnitude of the resultant of these forces by using trigonometry to first resolve each of the vectors into components and then finding the magnitude and direction of the summed components. This is a calculated, or in this case, "theoretical" value.

3. Use the three forces given to you to determine the direction and magnitude of the resultant of these forces by doing a scale drawing. This will be your graphical value. Make a reasonable estimate of the absolute uncertainties of the magnitude and of the direction of your graphical value.

4. Determine if your various values for the **magnitude** of the resultant force agree by comparing the percent difference with the percent uncertainty. (You have an experimental value (step 1), a calculated "theoretical" value (step 2) and a graphical value (step 3).) That is: compare the calculated value and the graphical value, the calculated value and the experimental value, and the graphical and experimental values?

5. Determine if the various values for the **angle** of the resultant force agree by comparing the absolute difference with the absolute uncertainly.