

# Vector Lab Teacher's Guide

## Objectives:

1. Use spring scales to show addition of force vectors.
2. Vector addition using tip-to-tail method and trigonometry.

## Materials:

Each group must have:

2 ring stands, 2 spring scales, 4 washers, 1 triple beam balance, paper clip

Each student must have:

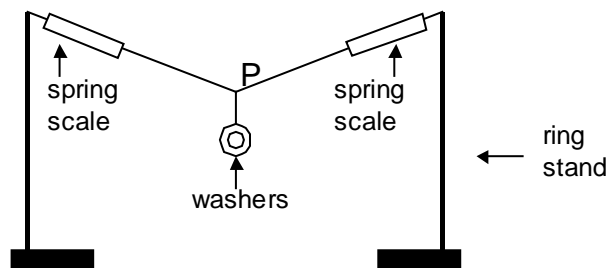
1 protractor, 1 ruler, 1 calculator

## Part A:

Part A involves a simple vector addition problem to be solved with both the tip-to-tail method and trigonometry. All the students need for this part is a ruler, protractor, and calculator. This is just meant to be a “warm-up” problem so they are ready for Part B. They should be able to understand that mathematical vector addition is probably more accurate than the tip-to-tail method, because it involves no physical measurements (at least for this problem).

## Part B:

Each group should have the following setup:



In part B, students will show that the sum of the forces on each spring scale equals the weight of the washers. They will use both the tip-to-tail method and trigonometry. They will have some error due to difficulty in measuring angles and mass. Make sure that the students know that if their spring scale measures mass, they need to convert it to force by multiplying by  $9.8 \text{ m/s}^2$ . They should be able to come within a 20% error using both methods, although they should have slightly less error using trigonometry.

Name: \_\_\_\_\_

## Vector Lab

### Objectives:

The purpose of this experiment is to use vectors to resolve forces in equilibrium.

### Materials:

2 ring stands, string, 2 spring scales, 4 washers, Protractor, Ruler, Calculator, 1 triple beam balance, paper clip

### Procedure:

A. Addition of displacement vectors using tip-to-tail method and trig.

A person walks 1 km due north from her house. She then turns and walks another 3 km in a direction of  $35^\circ$  north of east. Determine her total displacement (magnitude and direction) from her house using the following methods.

1. Tip-to-tail

Draw a coordinate system below such that the person's house is at the origin. Then choose an appropriate number scale (i.e.  $1 \text{ km} = X \text{ cm}$ ). Draw in your first vector (1 km N) with the tail at the origin. Begin the second vector ( $35^\circ$  N of E) at the tip of the first vector. Then add the two vectors by drawing a line from the origin (her house) to the tip of the second vector. Measure the magnitude and direction of the total displacement and report in the space provided.

Magnitude of total displacement \_\_\_\_\_

Direction of total displacement \_\_\_\_\_

2. Now add the vectors mathematically. Using trigonometry, determine the x and y components of each vector. The x-component of the total displacement is the sum of the x-components of each vector. Likewise, the sum of the y-components of each vector is the y-component of the total displacement.

$$A_x + B_x = C_x$$

$$A_y + B_y = C_y$$

Using the Pythagorean Theorem, we know that

$$C = \sqrt{C_x^2 + C_y^2}$$

The x- and y- components of each vector can be determined using trigonometry. Determine the magnitude and direction of the total displacement mathematically, showing your work and reporting your answer below.

Total magnitude of displacement \_\_\_\_\_

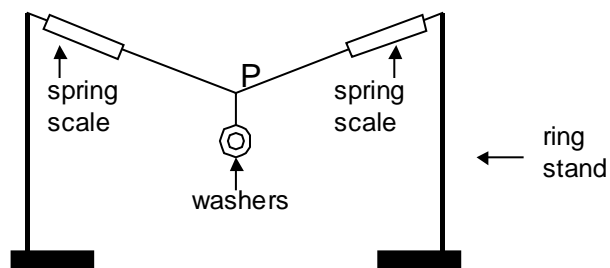
Total direction of displacement \_\_\_\_\_

Do these answers agree with those you found using the tip-to-tail method? \_\_\_\_\_

Which method do you think is more accurate? \_\_\_\_\_

**B. Addition of Force Vectors**

1. Set up your vector addition apparatus as shown in the figure below. For the hanging mass, use 4 washers. Measure the mass of your four washers before attaching them and report below. To attach the masses, use a paperclip as a hook.



Mass of four washers = \_\_\_\_\_ kg

2. Measure the three angles created by the string at point P. Using these angle measurements, construct a diagram of the forces acting on point P. Choose an appropriate number scale, and draw in the vectors on the force diagram. Next to your diagram, include your number scale. Label your vectors A (for the left spring scale), B (for the right spring scale), and W (for the hanging weight). Also show your coordinates.

3. Because the point, P, is not accelerating, the sum of the forces on point P is zero.

$$\sum F_p = A + B - W = 0$$

so

$$A + B = W$$

Use the tip-to-tail method to add A+B and get the resultant, C. Show your work, and report the magnitude and direction of the sum below.

Magnitude of  $A+B = C =$  \_\_\_\_\_ N

Direction of  $A+B = C =$  \_\_\_\_\_

Weight ( $m \times g$ ) of four washers = \_\_\_\_\_ N

4. Now add  $A+B=C$  mathematically, using trigonometry. Show your work below, and report the magnitude and direction in the space provided.

Magnitude of A+B=C = \_\_\_\_\_ N  
Direction of A+B=C = \_\_\_\_\_

4. Questions:

- 1) Does your value for the magnitude of C found by using the tip-to-tail method equal the weight of the four washers? Calculate the percent error by using:

$$\%error = \frac{|Weight - C|}{Weight} \times 100\%$$

- 2) Does your value for the magnitude of C found mathematically equal the weight of the four washers? Calculate the percent error, using the same equation as above.

- 3) Which method (tip-to-tail or trigonometry) proved to be more accurate? Why?

**Name:** \_\_\_\_\_

Vector Lab  
Prelab Questions

1. What is the goal of this lab?
2. What is the “tip-to-tail” method for adding vectors?
3. What are the x- and y-components of a vector that has a magnitude of 4 and a direction of  $30^\circ$ ?
4. In part B, what measurements do you need to make?