

## LAB 3. VECTOR ADDITION

### Introduction

This lab consists of two exercises. The first one involves calculating distances and angles of displacement vectors between different locations on campus. Based upon this information, you will calculate the distance between two other points on campus. The second exercise involves combining three forces to give a zero net force.

### Supplies

**Displacements:** protractor, long tape measure, sidewalk chalk, magnetic compass, graph paper

**Forces:** Force table, protractor, disk masses, graph paper

### Activities

#### Displacements

In this exercise, you become the instrument. Before you can be used to measure a distance, you must be calibrated. To do this, you will use a tape measure to calibrate your average pace size.

1. Mark off a 50-meter length on the sidewalk using the tape. Record how many paces it takes you to walk the 50-meter distance. Calculate the length of your pace in meters. You will use this calibration factor to calculate the distance in meters between various points around school.

Paces: \_\_\_\_\_ /50 m      Pace length: \_\_\_\_\_ m/pace

2. Determine the heading (in degrees) from the outside entrance to the swimming pool to the nearest telephone pole. Do this by placing the magnetic compass on the stool and sighting to the destination. Once it settles, the compass needle should point north. Read the heading from the line inscribed on the compass crystal.
3. Determine the distance from the entrance to the swimming pool to the nearest telephone pole by walking the distance and counting the number of paces. Convert the number of paces into meters by using the pace length factor from Step 1. These are the heading and magnitude of the vector  $\vec{A}$ , the displacement vector from the swimming pool entrance to the telephone pole.

$\vec{A}$ :      Length: \_\_\_\_\_      Heading: \_\_\_\_\_

4. In the same way, determine the heading and magnitude of  $\vec{B}$ , the displacement vector from the telephone pole to the entrance by the dining hall.

$\vec{B}$ :      Length: \_\_\_\_\_      Heading: \_\_\_\_\_

5. Prepare to draw vectors  $\vec{A}$  and  $\vec{B}$  to scale on a piece of graph paper. First, calculate the scale equivalence, then the lengths of the scaled vectors.

1 m on land = \_\_\_\_\_ mm on paper      Scaled  $A$ : \_\_\_\_\_ mm      Scaled  $B$ : \_\_\_\_\_ mm

6. Draw the scaled vector  $\vec{A}$ , then draw  $\vec{B}$ , beginning at the head of  $\vec{A}$ . Draw the resultant vector  $\vec{A} + \vec{B}$ . Measure its length with a ruler and heading with a protractor. Invert the scale.

$\vec{A} + \vec{B}$ : Scaled length: \_\_\_\_\_ Heading: \_\_\_\_\_ True length: \_\_\_\_\_

- Convert the heading angles to trigonometric angles. The compass uses the convention that North is  $0^\circ$ , and the angles increase clockwise. So we can convert the heading angles to the trigonometric angles by setting North as the direction of the  $+x$  axis and negating all the angles (or subtracting from  $360^\circ$ ).

$\vec{A}$  angle: \_\_\_\_\_  $\vec{B}$  Angle: \_\_\_\_\_

- Use these trigonometric angles to convert vectors  $\vec{A}$  and  $\vec{B}$  into their  $x$ - (North) and  $y$ - (West) components.

$A_x =$  \_\_\_\_\_  $A_y =$  \_\_\_\_\_  $B_x =$  \_\_\_\_\_  $B_y =$  \_\_\_\_\_

- Calculate the resultant vector  $\vec{A} + \vec{B}$  by adding the components of  $\vec{A}$  and  $\vec{B}$ .

$(A+B)_x =$  \_\_\_\_\_  $(A+B)_y =$  \_\_\_\_\_

- Convert  $\vec{A} + \vec{B}$  to magnitude (distance) and (trigonometric) direction.

$\vec{A} + \vec{B}$ : Distance: \_\_\_\_\_ Angle: \_\_\_\_\_

- Convert the direction of  $\vec{A} + \vec{B}$  back to a compass heading.

$\vec{A} + \vec{B}$ : Distance: \_\_\_\_\_ Heading: \_\_\_\_\_

- Compare the distance and heading of  $\vec{A} + \vec{B}$  found graphically (6) and by components (11).

**Force table**

The force table is a circle with three pulleys around the edge to support three threads tied to a central ring. Weights are hung from the threads and positioned on the circle so that the forces all cancel, centering the ring at the center of the table.

- Obtain the angles and masses for two of your weights from the instructor.

Mass 1: \_\_\_\_\_ Angle 1: \_\_\_\_\_ Mass 2: \_\_\_\_\_ Angle 2: \_\_\_\_\_

- Position two of the pulleys as directed and hang the directed masses from their threads. (Include the masses of the hooks.)

- Determine the mass and angle that should produce the equilibrant vector that combines with the other two tensions to yield a zero net force on the ring. You may determine this any way you like: graphically, by calculation, or by trial and error. Write it here.

Equilibrant: Mass: \_\_\_\_\_ Angle: \_\_\_\_\_

- Once you have determined the correct equilibrant, summon your instructor to witness that the two given vectors are correct and the equilibrant actually equilibrates. (If it doesn't, you get one more try.)