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LAB 3. VECTORS

Introduction

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

Supplies

Displacements: protractor, trundle wheel, sidewalk chalk, orienteering compass, graph paper
Forces: Force table, three pulleys, central ring with three leads, mass hanging hooks, protractor, disk masses, graph paper

Activities

Outdoor displacements

Measurements

In this exercise, you become an instrument. Before you can be used to measure a dimension, you must be calibrated. To do this, you will use a trundle wheel to calibrate your average pace length.

1. Mark off a 50-meter length on the sidewalk using the one meter trundle wheel. Oh wait, I bought the trundle wheel in the USA, so it measures in feet instead of in meters. So, the first thing you need to do is convert 50 m to feet, so that you know how many feet to measure to make a 50-m segment. Here are some equalities you can use to carry out the conversion:

   - 1 ft = 12 in
   - 1 in = 2.54 cm
   - 1 m = 100 cm

   Set up and carry out the conversion of 50 m to feet below.

   50 m · = ________ ft

2. Record how many paces it takes you to walk the 50-meter distance.

   50 m = _______________ paces

   Calculate the length of one meter in stride lengths.

   1 m = ________________ paces

   You will use this conversion factor to calculate the distance in meters between a few points on campus.

3. Determine the heading (in degrees) from the front (Lewis Street) entrance of the Enzi STEM Building to the Emergency kiosk by the Berry Center. Do this by holding the

magnetic compass level and sighting to the destination. The compass needle should point north once it settles. Read the heading from the compass.

Heading: ______________

4. Determine the distance from the Enzi Building entrance to the Berry Center emergency kiosk by walking the distance and counting the number of paces. Convert the number of paces to meters by using the conversion factor from Step 2.

   Paces: __________ Meters: ____________

5. In the same way, determine the heading and distance from the Berry Center emergency kiosk to the electrical transformer between the Enzi building and the Science Initiative building. Convert the number of paces to meters using the conversion factor from Step 2.

   Heading: ________ Paces: _____________ Meters: ____________

Data Processing

1. Refer to these two displacements as vector $\vec{A}$, from the STEM building to the emergency kiosk, and $\vec{B}$, from the kiosk to the transformer. 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

2. 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 to find the actual length of displacement $\vec{A} + \vec{B}$.

   $\vec{A} + \vec{B}$: Scaled length: ________ Heading: _________ True length: ___________

3. Now find the vector sum by components. Convert the displacement vectors $\vec{A}$ and $\vec{B}$ into *x* (North) and *y* (East) Cartesian components.

   A_x = _________ A_y = ___________ B_x =__________ B_y = ___________

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

   $(A+B)_x$ = __________ $(A+B)_y$ = ____________

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

   $\vec{A} + \vec{B}$: Distance: ______________ Angle: ________________

12. Compare the distance and heading of $\vec{A} + \vec{B}$ found graphically (2) and by components (5).

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Force table

The force table is a circle with three pulleys around the edge to support three or four 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.

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

   Mass 1: ________   Angle 1: ________   Mass 2: ________   Angle 2: ________

2. Center the ring on the retractable bollard at the center of the force table. Position two of the pulleys as directed and hang the directed masses, including the masses of the hooks, from their threads.
3. 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. You may even show your work below. Write your prediction here.

   Equilibrant: Mass: _____________   Angle: _______________

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