SPH3U: Two-Dimensional Motion

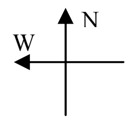
The main model of motion we have developed so far is uniform acceleration in a straight line. But the real world can be much more complex than this! When we walk, bike or drive, we change directions, hang a left, or go west. These are examples of two dimensional motion, or motion in a plane.

Recorder: ___________________
Manager: ___________________
Speaker: ___________________
0 1 2 3 4 5

A: Let's Take a Walk

When depicting two-dimensional motion we use vector arrows to represent each step in our journey. These vectors are drawn according to a scale and a coordinate system. You will need a ruler and protractor for this investigation.

1. Your friend walks 7 m south and then 5 m east. Illustrate this using two vector arrows, one after the other.



1 cm = 1 m

2. Remind yourself: What is the definition of displacement? Write it here.

3. Draw a single vector arrow which represents the total displacement for your friend's entire trip.

4. Roughly speaking, in what direction does this new vector point? Explain how to use the diagram to determine the direction very carefully. Determine this now.

5. Explain how to use the diagram to determine how far your friend is from her starting point. Determine this now.

Writing down vectors in two dimensions becomes tricky. Our simple technique of using sign conventions will not easily work. We now use a special vector notation. Imagine someone travels 3.5 m in a direction North and 60° to the West. We will record this by writing: $\Delta\vec{d} = 3.5\ m\ [N60^{o}W]$. The symbol $\Delta\vec{d}$ with an arrow signifies a displacement (a change in the position vector). The number part, 3.5 m, is called the magnitude of the vector. The angle that is used is always between zero and 90°, and is measured at the tail of the vector.

6. Label the three vectors in your diagram as $\Delta\vec{d}_1$, $\Delta\vec{d}_{2,}$ *and* $\Delta\vec{d}_t$ following the example described above including the magnitude, unit and direction.

7. The vector diagram we have drawn above is actually a picture of an equation where two quantities added together give a third quantity, the total. Write down the equation represented by your diagram.

Note that whenever vectors are added together to give a total, they are drawn *tip to tail*, just as you have done above.

Part B: Distance Verses Displacement, Speed Verses Velocity

1. Remind yourself: What is the definition of distance? Write it here.

2. Determine the total distance your friend travels. Compare this with the magnitude of the total displacement. Explain why these quantities are different.

3. Give an example of a situation where the displacement of an object is zero, but the distance is not. Draw a diagram to help explain why.

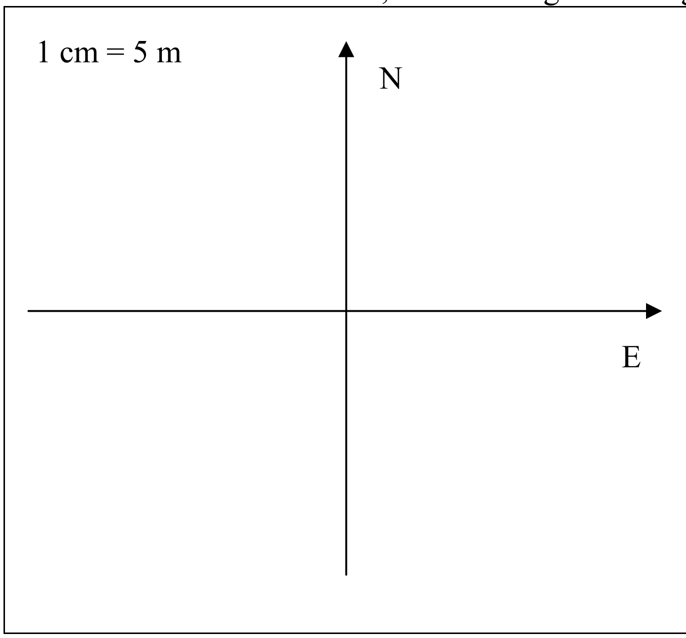
4. We want to calculate your friend's velocity during this trip. What type of velocity will this be: instantaneous or average? Explain.

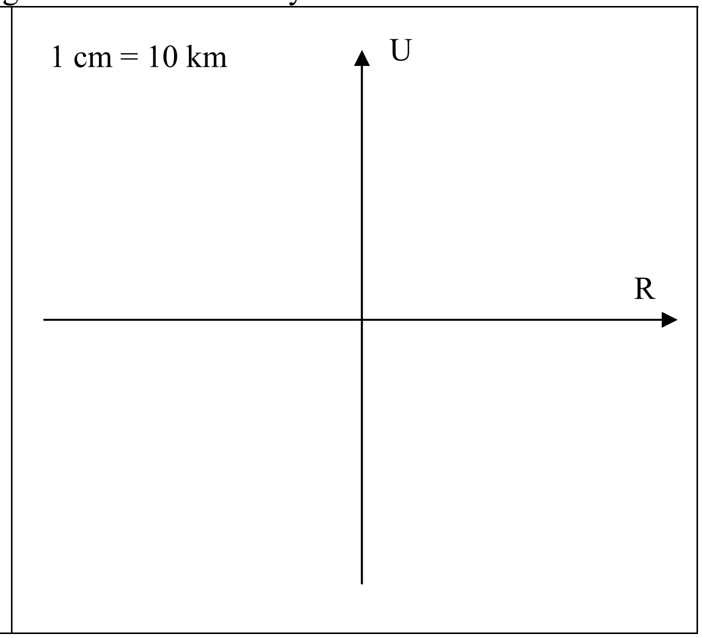
5. Remind yourself: What is the definition of average velocity? What is the definition of average speed? Write these here.

6. Your stopwatch shows that it took your friend 11.0 seconds to make her trip. Calculate her average velocity and her average speed. Use the new vector notation for the velocity calculation.

SPH3U: Vector Practice

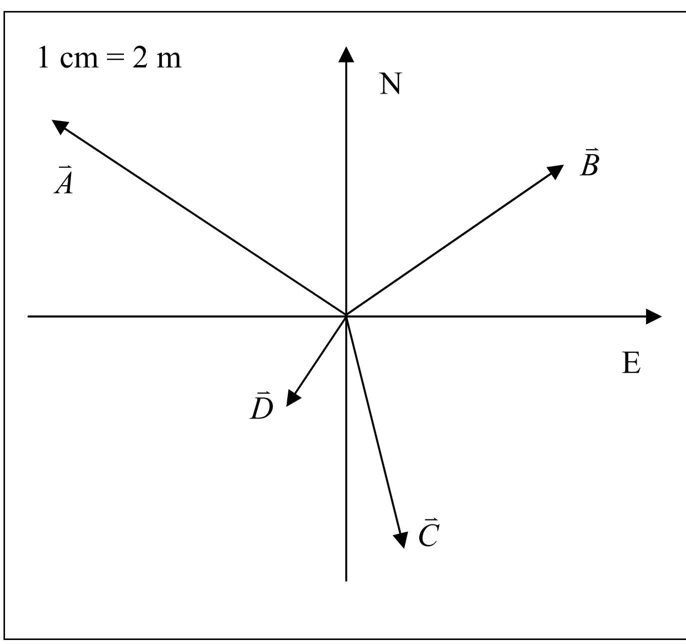
1. Draw each vector to scale, each starting at the origin of the coordinate system.

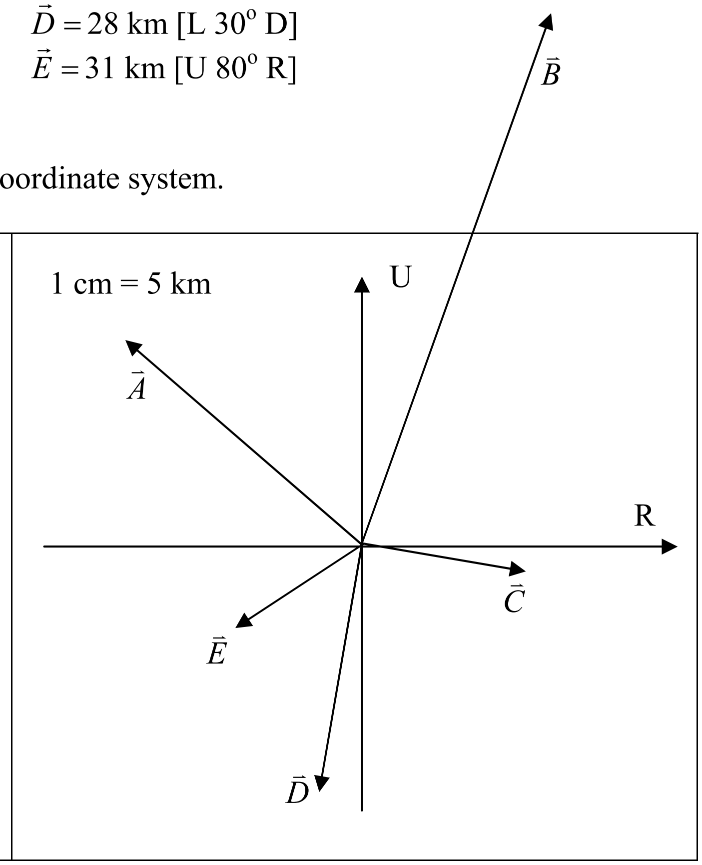




$\vec{A} = 10$ m [E]	$\vec{A} = 15$ km [D]
$\vec{B} = 25$ m [N 30°W]	$\vec{B} = 20$ km [U 45°L]
$\vec{C} = 42$ m [S 10° E]	$\vec{C} = 50$ km [R 15° U]
$\vec{D} = 35$ m [W 70° S]	$\vec{D} = 28$ km [L 30° D]
$\vec{E} = 32$ m [E 80° N]	$\vec{E} = 31$ km [U 80° R]

2. Measure each vector according to the scale and coordinate system.





3. Find the total displacement for each trip by adding the two displacement vectors together tip-to-tail. Complete the chart assuming the whole trip took 1 h. Use the scale 1 cm = 10 km. Don't worry if your vectors go outside the boxes!

Vectors	Diagram	Total Displ.	Total Dist.	Avg. Velocity	Avg. Speed
40 km [E] 30 km [E]					
40 km [E] 30 km [N]					
40 km [E] 30 km [W]					
40 km [E] 30 km [E30°N]					
40 km [E] 30 km [S50°W]					