# Workshop Tutorials for Introductory Physics

# MI2: **Using Vectors**

## A. Review of Basic Ideas:

**Use the following words to fill in the blanks:**

*always*, magnitude, $A_y\hat{\mathbf{j}}$, displacement , $A_y + B_y$, directions, far, pointing, 20 km, vectors, origin, Cartesian, A$\cos\theta$, home

**A sense of direction**

Every one has at some point asked someone else for _____ or given someone else directions to get somewhere. When you listen to someone describing how to get to a place they *sometimes* talk about how _____ to walk or drive, but they _____ describe which direction to travel in. They may do this by simply _____, or saying keep going straight, or go left, then right, or go west then north. If you live 20 km from university, then you need to travel at least _____ to get there. But if you go 20 km in the wrong direction, you will not get there. A knowledge of direction is something you use all the time.

Direction is very important in physics as well. A lot of the quantities that we talk about in physics have a direction. Common examples are _____, momentum, and force. To describe these quantities we use _____.

A vector has both a _____ (which tells you how big it is) and a direction. There are lots of different ways of representing vectors, some of which you regularly use already. If someone asks you where Hurstville is you might say "about 20km south west of the city", or you might give them a map reference, such as "map 75, grid reference H6". Usually we need to define some reference point, called an _____, so that we know where we're measuring from, and some directions such as north, south, east and west, up and down. In physics we usually use _____ coordinates, which are commonly labeled *x,y* and *z.*

We can describe a vector by giving its components in each of the coordinate directions. To do this we need to define unit vectors. Unit vectors have a length or magnitude of 1, and point in the direction of the axes. The unit vector $\hat{\mathbf{i}}$ points in the direction of the *x* axis and the unit vector $\hat{\mathbf{j}}$ points in the y direction. In 2 dimensions, a vector $\vec{\mathbf{A}}$ could be written as $\vec{\mathbf{A}} = A_x\hat{\mathbf{i}}$ + _____. The magnitude of the vector $\vec{\mathbf{A}}$ is

$$\mathrm{A} = \sqrt{A_x^2 + A_y^2}$$

Given the angle, θ, that the vector makes with the *x* axis and the magnitude of the vector, we can find the components:

$A_x =$ _____ $\qquad A_y = \mathrm{A}\sin\theta$

If you know what the components are it's easy to add vectors. If you add a vector $\vec{\mathbf{A}}$ to a vector $\vec{\mathbf{B}}$ you get a resultant vector, which we'll call **C**,

$\vec{\mathbf{C}} = \vec{\mathbf{A}} + \vec{\mathbf{B}}$ and $C_x = (A_x + B_x)$ and $C_y =$ (_____) so

$\vec{\mathbf{C}} = C_x\,\hat{\mathbf{i}} + C_y\,\hat{\mathbf{j}} = (A_x + B_x)\,\hat{\mathbf{i}} + (A_y + B_y)\,\hat{\mathbf{j}}$ .

If the vector $\vec{\mathbf{A}}$ describes how to get from home to the beach, and the vector $\vec{\mathbf{B}}$ describes how to get from the beach to Uni, then the sum, $\vec{\mathbf{C}}$ , tells you how to get directly from _____ to Uni.

**Discussion question**

Explain to your team (just one of you) how to get from your home to the local shop. Listen for vectors, and try to draw them.

## B. Activity Questions:

**1. Battleship**
Describe how vectors are used to give positions in this game.
How else could you describe the position of a ship?

**2. Map**
How are vectors used on the maps?
You should be able to find at least two examples.

**3. Vector Game**
Appoint one group member to be a caller.
Everyone else chooses a starting position and walks the vectors as called.
When you get it wrong, you're out!

**4. Mirrors and reflections - Coordinate Systems**
Look at your reflection in the mirror.
Move your right hand to the right. What does your reflection do?
Why is it that left and right are reversed in the mirror, but not up and down?

## C. Qualitative Questions:

**1.** Barry the dog is running around the yard chasing a ball.
**a.** Can the magnitude of Barry's displacement be less than the distance he's travelled?
**b.** Can the displacement be more than the distance traveled?
Barry comes to rest in the yard, some distance from where he started. Consider the components of his displacement in perpendicular directions (such as north and east, or $x$ and $y$.)
**c.** Can the magnitude of any of these components be greater than the magnitude of the displacement vector itself?
**d.** How could a component have the same magnitude as the magnitude of his displacement vector?

**2**. Vectors are very useful for describing velocities. Have you ever watched a bird trying to fly in a strong wind? They can appear to be standing still or even going backwards if flying against the wind.
Kevin the Tasmanian duck is heading north for winter over Bass Strait. He flies with a velocity $\vec{\mathbf{K}} = K_x\hat{\mathbf{i}} + K_y\hat{\mathbf{j}}$. He gets almost within sight of the Victorian coast line when a strong wind begins to blow with a velocity $\vec{\mathbf{W}} = W_x\hat{\mathbf{i}} + W_y\hat{\mathbf{j}}$, blowing Kevin off course.
**a.** Write an expression for the resultant velocity, $\vec{\mathbf{V}}$, of the bird.
**b.** Draw a diagram showing the vectors $\vec{\mathbf{W}}$, $\vec{\mathbf{K}}$ and $\vec{\mathbf{V}}$.
**c.** Are the components of $\vec{\mathbf{V}}$ necessarily larger than the components of $\vec{\mathbf{K}}$ and $\vec{\mathbf{W}}$?

## D. Quantitative Question:

A radar operator is tracking the movements of a ship. When she first notices the ship it is 20 km south of her. An hour later it is 10 km south and 10 km east of her.
**a.** Draw a diagram showing the ship and radar station initially and an hour later.
**b.** Take the radar station as the origin, and write vectors giving the initial position of the ship, and its position one hour later.
**c.** What is the velocity of the ship (as a vector), in kilometers per hour, $km.h^{-1}$?
**d.** What is the magnitude of the velocity?
The ship continues at a steady pace in the same direction.
**e.** Write an expression for the displacement of the ship at any time.