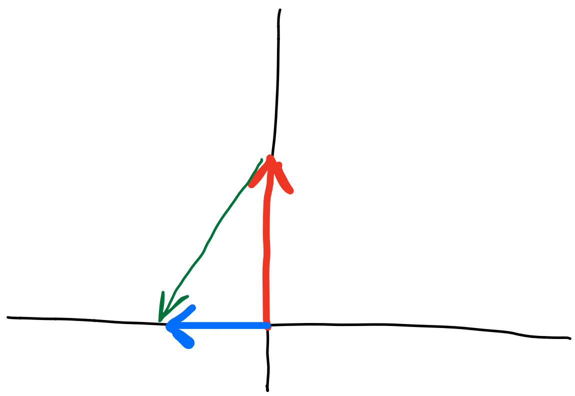
Q1.4.c

$\vec{r}_p = \langle 0, 3, -2 \rangle$ m

$\vec{r}_e = \langle -1, 0, -6 \rangle$ m



$\vec{r} = \vec{r}_e - \vec{r}_p$

$\vec{r} = \langle -1, 0, -6 \rangle$ m $- \langle 0, 3, -2 \rangle$ m

$\vec{r} = \langle -1, -3, -4 \rangle$ m

Q1.4.e

$\vec{r} = \langle 3, 5, -2 \rangle$ m

$\hat{r} = ?$

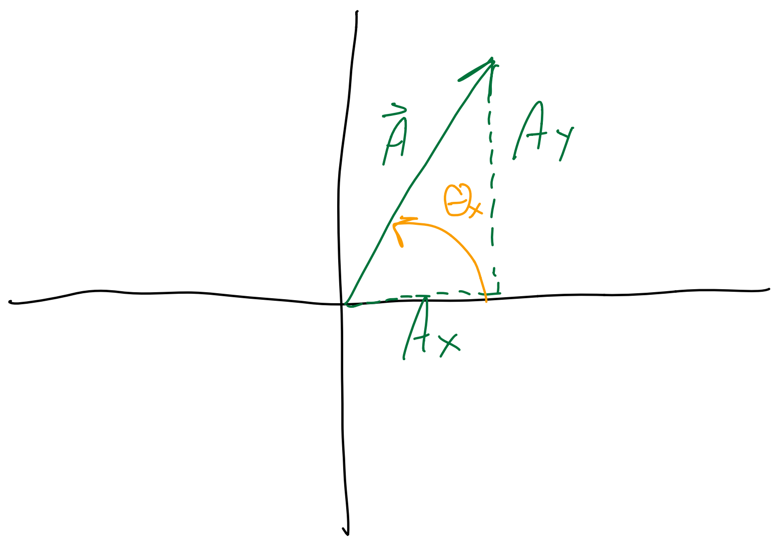
$$\hat{r} = \frac{\vec{r}}{|\vec{r}|}$$

$$|\vec{r}| = \sqrt{3^2 + 5^2 + (-2)^2} = 6.16$$

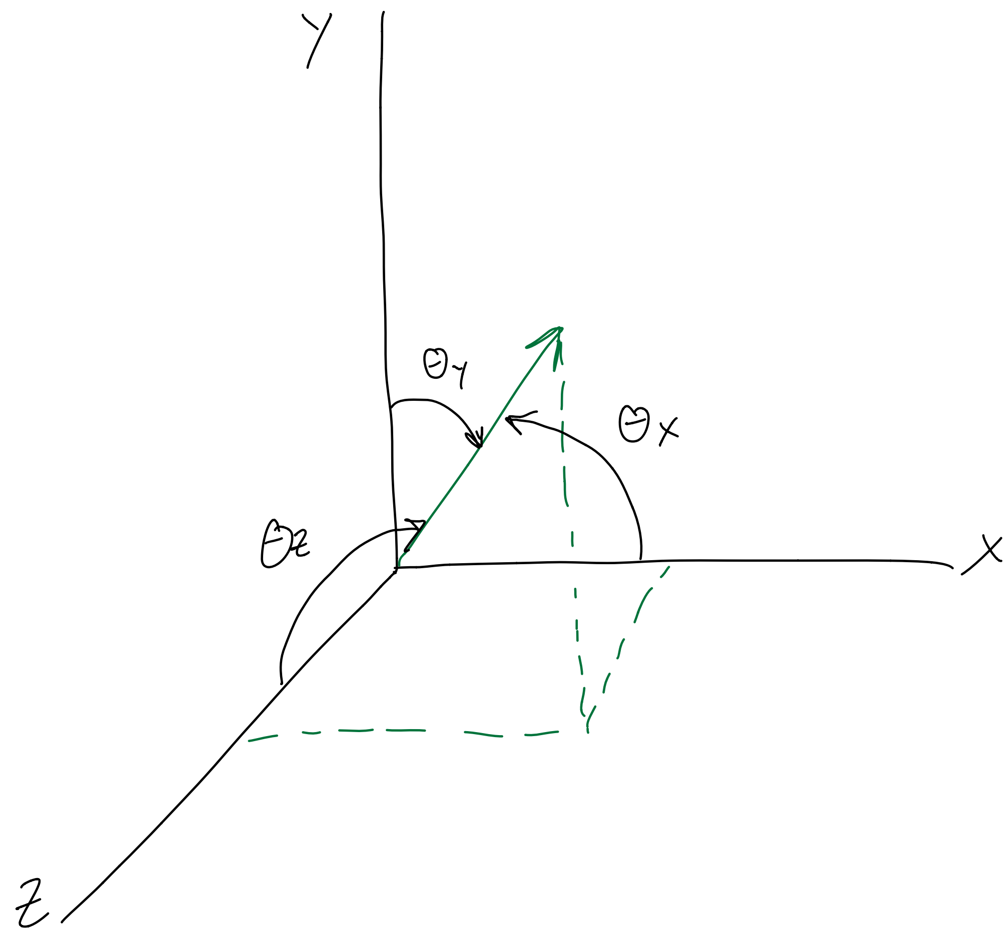
$$\hat{r} = \frac{1}{6.16} \langle 3, 5, -2 \rangle$$

$$= \langle 0.49, 0.81, -0.32 \rangle$$

Another way to describe unit vectors



$$A_x = \cos(\theta_x)$$



$$\hat{r} = \langle \cos\Theta_x, \cos\Theta_y, \cos\Theta_z \rangle$$

Example

A golf ball is hit of the tee w/ velocity

$$\vec{v} = \langle 80, 60, 0 \rangle \frac{m}{s}$$

speed: $|\vec{v}| = \sqrt{80^2+60^2} = 100 \frac{m}{s}$

Direction:

$$\hat{v} = \frac{\vec{v}}{|\vec{v}|} = \frac{1}{100} \langle 80, 60, 0 \rangle$$

$$\hat{v} = \langle \frac{4}{5}, \frac{3}{5}, 0 \rangle$$

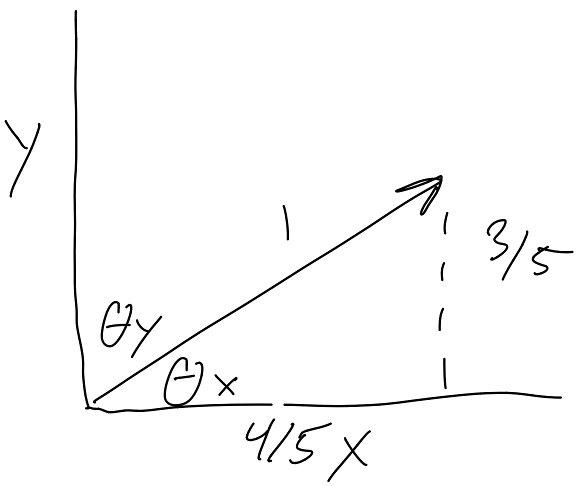
What is θ_x? θ_y? θ_z?

$$\hat{v} = \langle \cos\theta_x, \cos\theta_y, \cos\theta_z \rangle$$

$$\cos\theta_x = \frac{3}{5}$$

$$\theta_x = \cos^{-1}\left(\frac{4}{5}\right) = 0.64 = 37^\circ$$

$$\theta_y = \cos^{-1}\left(\frac{3}{5}\right) = 0.93 = 53^\circ$$



What is velocity?

We know what speed is

- Velocity is the rate of change of position

If I start at some initial position called $\vec{r}_i$ at some initial time t_i, and move to some separte position $\vec{r}_f$ by time t_f, the

$$\vec{V}_{avg} = \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i}$$

Did this yesterday in lab!

A few notes:

- Time is a scalar, so $t_f - t_i$ is a scalar
- $\vec{r}_f - \vec{r}_i$ is a vector
- $\vec{V}_{avg}$ is a vector

Really 3 equations

$$\langle V_{av,x}, V_{av,y}, V_{av,z} \rangle = \frac{\langle x_f, y_f, z_f \rangle - \langle x_i, y_i, z_i \rangle}{t_f - t_i}$$

$$V_{av,x} = \frac{x_f - x_i}{t_f - t_i}$$

$$V_{av,y} = \frac{y_f - y_i}{t_f - t_i}$$

- We use final − initial so that $\vec{V}_{avg}$ points in the direction of motion

This concept of final − initial is so important that we have special notation for it

$$\Delta \vec{r} = \vec{r}_f - \vec{r}_i$$

$$\Delta t = t_f - t_i$$

Δ: Greek letter "delta"

change

$$\vec{v}_{avg} = \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i} = \frac{\Delta \vec{r}}{\Delta t}$$

Ex: the bee in flight

$\vec{r}_i = \langle 2, 4, 0 \rangle \, m \quad \vec{r}_f = \langle 3, 3.5, 0 \rangle \, m$

$t_i = 15 \, s$, $t_f = 15.5 \, s$, $\Delta t = 0.5 \, s$

$\Delta \vec{r} = \langle 1, -.5, 0 \rangle$, $\vec{v} = \frac{\Delta \vec{r}}{\Delta t} = \langle 2, -1, 0 \rangle \frac{m}{s}$

Note: $\vec{v}_{avg}$ is not avg speed

Indy 500?

Note: if I know the position and velocity of an object at a certain time, I can use them to predict the position of the object at some later time.

-Only works if velocity is constant!

$$\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t}$$

$$\Delta \vec{r} = \Delta t \, \vec{v}_{avg}$$

$$\vec{r}_f - \vec{r}_i = \Delta t \, \vec{v}_{avg}$$

$$\vec{r}_f = \vec{r}_i + \Delta t \, \vec{v}_{avg}$$

Ex: A bird flies at constant velocity. At one moment, you see the bird at position $\vec{r}_i = \langle 5, 9, -3 \rangle$ m, flying w $\vec{v}_{avg} = \langle 10, 0, 5 \rangle \frac{m}{s}$.

What will the position be in 5 s?

$$\vec{r}_f = \vec{r}_i + \Delta t \, \vec{v}_{avg}$$

$$= \langle 5, 9, -3 \rangle \text{m} + 5\text{s} \cdot \langle 10, 0, 5 \rangle \tfrac{\text{m}}{\text{s}}$$

$$= \langle 5, 9, -3 \rangle \text{m} + \langle 50, 0, 25 \rangle \text{m}$$

$$\boxed{\vec{r}_f = \langle 55, 9, 22 \rangle \text{m}}$$

Q 1.7.b