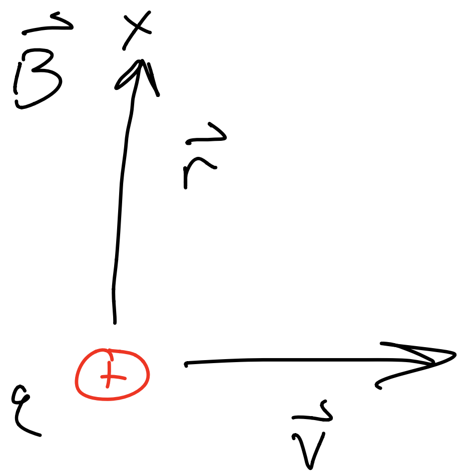
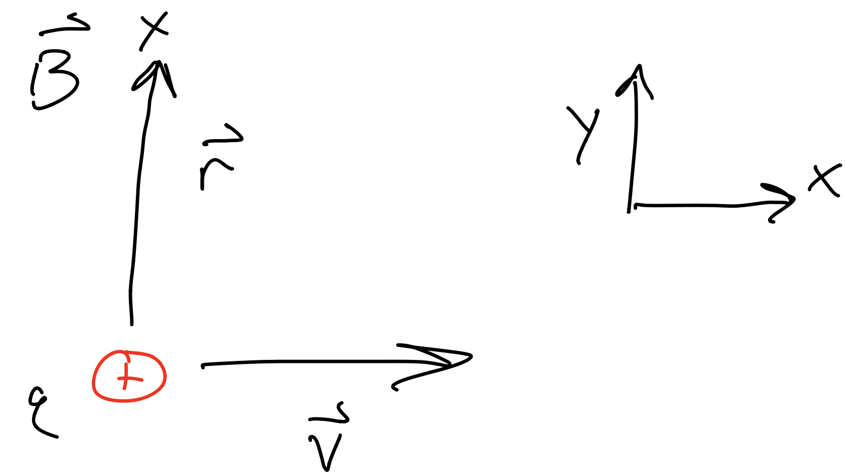
- So far:
    - We have considered stationary charges
    - Stationary charges produce electric fields, which exert a force on other stationary charges
    - Now we want to consider the case of *moving* charges

Moving charges = Magnetic field



Mag of $\vec{B}$: Decrease with distance $\left(\frac{1}{r^2}\right)$

Increase with both q & v



Direction of $\vec{B}$?

"Out of the page"

($\hat{z}$)

if $\vec{v}$ is in $\hat{x}$, $\vec{r}$ is $\hat{y}$, $\vec{B}$ is $\hat{z}$

$\hat{v}$	$\hat{r}$	$\hat{B}$
$\hat{x}$	$\hat{y}$	$\hat{z}$
$\hat{y}$	$\hat{z}$	$\hat{x}$
$\hat{z}$	$\hat{x}$	$\hat{y}$

Vector Cross product

$$\vec{B} = \text{const}\left(\frac{q\,\vec{v}\times\hat{r}}{r^2}\right)$$

$$\vec{r} = \vec{r}_{obs} - \vec{r}_{src}$$

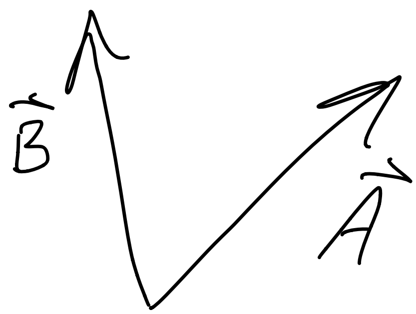
$$\vec{v} = \vec{v}_{src}$$

Cross Product

$$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$$

Direction: $\perp$ to both vectors

Right hand rule

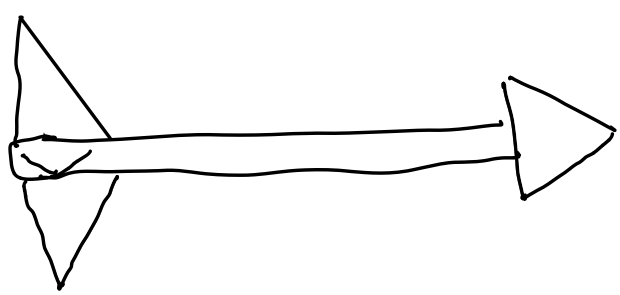


Direction of $\vec{A} \times \vec{B} = \odot$

"out of the page"

Direction of $\vec{B} \times \vec{A} = \otimes$

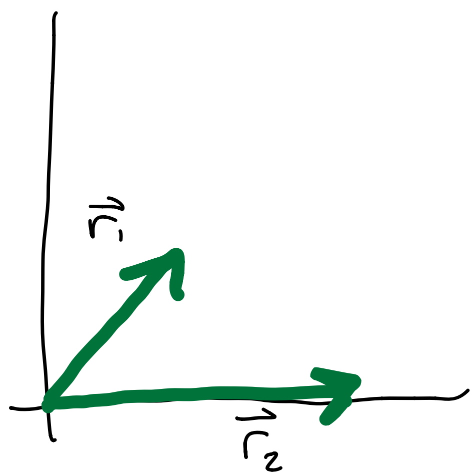
"into the page"



Ex: $\vec{r}_1 = \langle 1, 1 \rangle$

$\vec{r}_2 = \langle 0, 2 \rangle$

what is $\vec{r}_1 \times \vec{r}_2$?



Magnitude:

$$|\vec{A} \times \vec{B}| = |\vec{A}|\,|\vec{B}| \sin\theta$$

$$|\vec{r}_1 \times \vec{r}_2| = |\vec{r}_1|\,|\vec{r}_2| \sin\theta$$

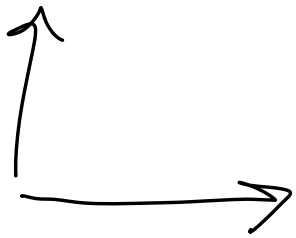
$\otimes$

$$|\vec{r}_1| = \sqrt{2} \quad , \quad |\vec{r}_2| = 2$$

θ ? $\quad \tan\theta = \frac{1}{1} \Rightarrow \theta = \frac{\pi}{4}$

$$|\vec{r}_1 \times \vec{r}_2| = (\sqrt{2})(2)\sin\left(\frac{\pi}{4}\right) = 2$$

What is $\hat{x} \times \hat{y}$?

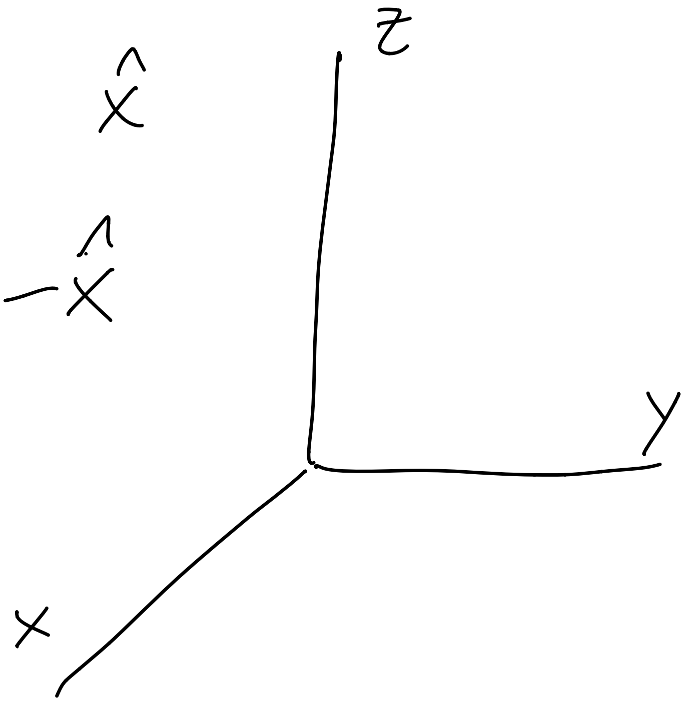


mag = 1, dir = $\odot$ ($\hat{z}$)

$\hat{x} \times \hat{x}$? 0

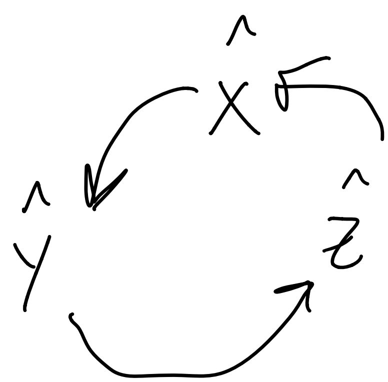
$\hat{y} \times \hat{z}$? $\hat{x}$

$\hat{z} \times \hat{y} = -\hat{x}$



vector 1

	$\hat{x}$	$\hat{y}$	$\hat{z}$
$\hat{x}$	0	$\hat{z}$	$-\hat{y}$
$\hat{y}$	$-\hat{z}$	0	$\hat{x}$
$\hat{z}$	$\hat{y}$	$-\hat{x}$	0



counter-clockwise : pos

clockwise : neg