Jan 7

Some class info…

$\vec{r} = \langle -3, -1, 5 \rangle \, m$

How far is the dot to table?

$|\vec{r}| = \sqrt{3^2 + 1^2 + 5^2} \, m = 5.9 \, m$

What is direction from dot to table?

$\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \frac{\langle -3, -1, 5 \rangle \cancel{m}}{5.9 \, \cancel{m}}$

3D Vectors

3 ways to multiple something times vector

1) Multiply by scalar

$$a\vec{r} = a\langle r_x, r_y, r_z\rangle = \langle ar_x, ar_y, ar_z\rangle$$

2) Multiply vectors times vector to form scalar

Scalar product or dot product

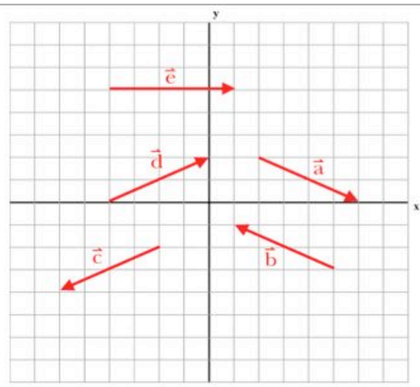
$$\vec{a}\cdot\vec{b} = a_x b_x + a_y b_y + a_z b_z = ab\cos\theta$$

3) Multiply vector by vector to form vector

Vector product $\vec{a}\times\vec{b} = \langle a_y b_z - a_z b_y, a_z b_x - a_x b_z, a_x b_y - a_y b_x\rangle$

$|\vec{a}\times\vec{b}| = ab\sin\theta$ RHR to find direction

Clicker Questions 1 & 2



1. Which of these arrows represents the vector < -4, 2, 0>?

A) $\vec{a}$
B) $\vec{b}$
C) $\vec{c}$
D) $\vec{d}$
E) $\vec{e}$

-4x ←

2 What is the magnitude of the vector < 3, 5, -2 >?

A) 5.48
2) 6.16
3) 6.00
4) 30.00
5) 38.00

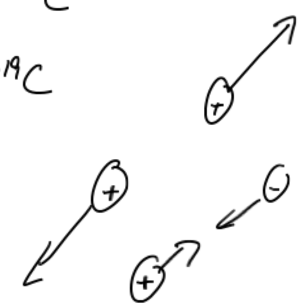
Discussion: Multiplying vectors

Discussion: Electric Forces

proton charge $= +e = 1.6 \times 10^{-19}C$

electron charge $= -e = -1.6 \times 10^{-19}C$

neutron charge $= 0$

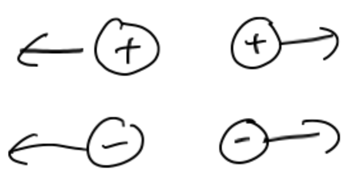


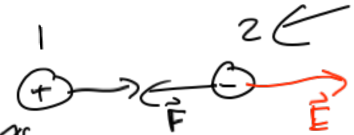
Tangible: From force to field

Discussion: Electric field concept

Discussion: Electric Forces

Tangible: From force to field





affected charge

inverse square law

$\vec F \propto \frac{1}{r^2}$

call source

Discussion: Electric field concept

$$\boxed{\vec F_{2\,\text{due to}\,1} = q_2 \vec E_1}$$

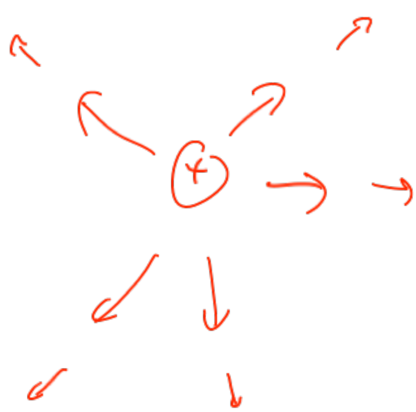
Memorize

$\vec E$ has units $\frac{N}{C}$

$\vec E$ points away from positive towards negative charges

Drawing convention

We place tail of arrow at position that we are measuring the field



Discussion: Coulomb Force

$$\boxed{\vec{F}_{2\text{ by }1} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{|\vec{r}|^2}\hat{r}}$$ Memorize

affective   source

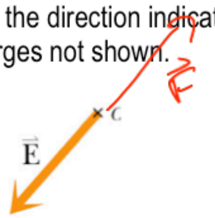
$$\frac{1}{4\pi\epsilon_0} = 9\times10^9 \ \frac{N\cdot m^2}{C^2}$$

$\vec{r} = \vec{r}_2 - \vec{r}_1$

points from 1 (source) to 2

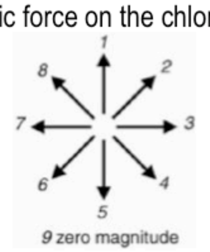
$\vec{F}_{1\text{ by }2} = -\vec{F}_{2\text{ by }1}$ (only thing that changes is $\hat{r}$)

At location *C* there is an electric field in the direction indicated, due to charges not shown.



A chloride ion (Cl^-) is placed at location C.

What is the direction of the electric force on the chloride ion?



A. Direction 2
B. Direction 4
C. Direction 6
D. Direction 8
E. Zero magnitude (9)

Cl^- negative

$\vec{F} = (-e)\vec{E}$

$-\vec{E}$ flips direction of vector

There is an electric field at location *A*, due to charged particles nearby. A proton placed at location *A* experiences an electric force of $\langle 0, -4.8\times 10^{-16}, 0\rangle$ N. What is the electric field at location *A*? *e* = 1.6e-19 C	A) $\langle 0, -4.8\times 10^{-16}, 0\rangle$ N/C B) $\langle 0, 4.8\times 10^{-16}, 0\rangle$ N/C C) $\langle 0, 1.6\times 10^{-19}, 0\rangle$ N/C D) $\langle 0, -3\times 10^{3}, 0\rangle$ N/C E) $\langle 0, 3\times 10^{3}, 0\rangle$ N/C

$$\vec{F} = q\vec{E}$$

$$= +e\vec{E} \Rightarrow \vec{E} = \frac{\vec{F}}{(+e)} = \frac{\langle 0, -4.8e^{-16}, 0\rangle \text{N}}{1.6e{-19}\text{C}}$$

$$= \langle 0, -3e3, 0\rangle \frac{\text{N}}{\text{C}}$$

Ponderable: Calculating *E* field

Proton at origin

What is electric field at location $\langle 3,-4,0\rangle$ m?

$$\vec{F}_{2\,by\,1} = q_2 \vec{E}_1 = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$$

$$\vec{E}_1 = \frac{1}{4\pi\epsilon_0}\frac{q_1}{r^2}\hat{r}$$

$\vec{r}$ = position measuring field ($\langle 3,-4,0\rangle$ m) − position of source (origin in this case)

$\vec{r} = \langle 3,-4,0\rangle$ m $\quad \hat{r} = \frac{\vec{r}}{r} = \langle \frac{3}{5}, -\frac{4}{5}, 0\rangle$

$|\vec{r}| = 5$ m

$$\vec{E}_1 = 9\times10^9 \frac{N\cdot \cancel{m^2}}{C^{\cancel{2}}} \frac{1.6\times10^{-19}\,\cancel{C}}{25\,\cancel{m^2}} \langle \frac{3}{5}, -\frac{4}{5}, 0\rangle$$

$$= \langle 3.5e{-11}, -4.6e{-11}, 0\rangle \frac{N}{C}$$