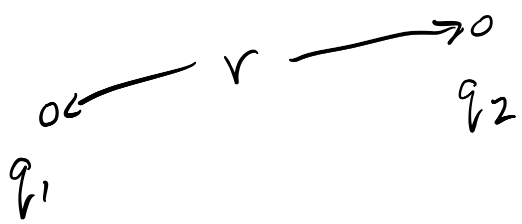
PHYS 121 Jan. 17, 2024

<u>To do</u>:

- Complete HW1 by 23:59 tonight. Jan. 17
- Complete HW2 by 23:59 on Fri. Jan. 19
- Labs & Tutorials start the week of Jan. 22
- Lab #0 next week ⇒ no pre-lab.

<u>Last time</u>: Coulomb's Law

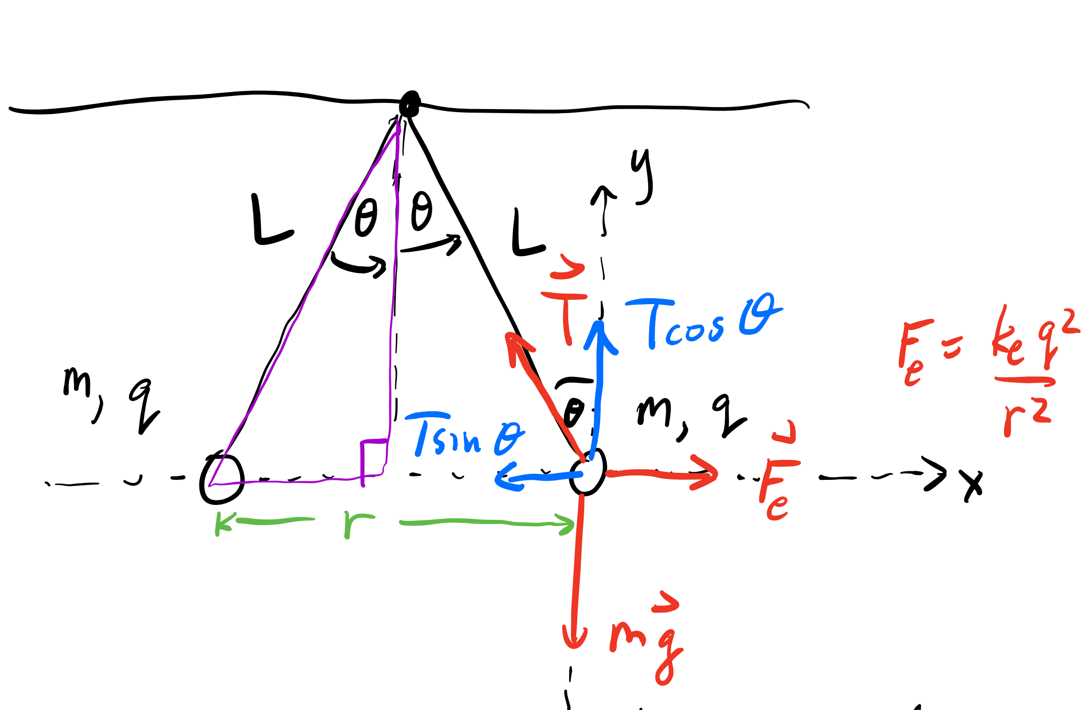



$$|\vec{F}_{12}| = |\vec{F}_{21}| = \frac{k_e q_1 q_2}{r^2}$$

$$k_e = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \frac{Nm^2}{C^2}$$

$$\varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$$

Example:



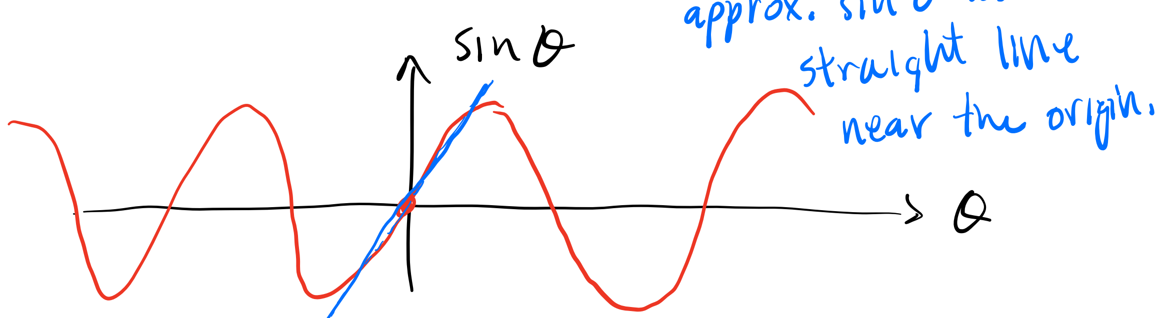

Suspend identical masses m with identical charges q from strings of length L. Find the value of θ.

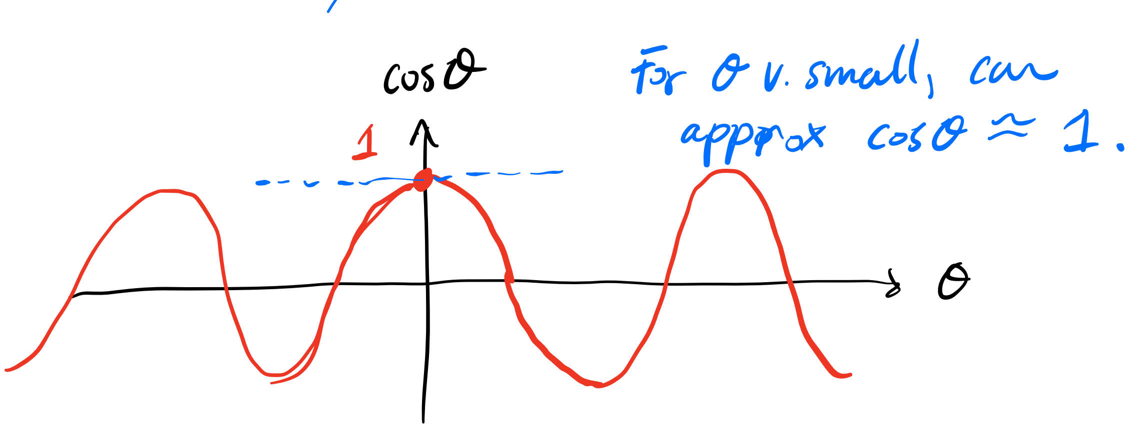
Found: $$\frac{\cos\theta}{\sin^3\theta} = \frac{4mgL^2}{k_e q^2} \quad (*)$$

To find an expression for θ, we will assume that θ is small & make some approximations.

Know that for small θ we can approx.

$$\sin\theta \simeq \theta$$






For small angles, can approx

$$\frac{\cos\theta}{\sin^3\theta} \approx \frac{1}{(\theta)^3}$$

Then ⊛ becomes

$$\frac{1}{\theta^3} \approx \frac{4mgL^2}{k_e q^2}$$

s.t. $\boxed{\theta \simeq \left(\frac{k_e q^2}{4mgL^2}\right)^{1/3}}$ in radians.

# Vector form of Coulomb's Law

Goal: Include information about dir'n of force in Coulomb's Law.


Define a unit vector $\hat{r}_{12}$

- a vector of length 1: $|\hat{r}_{12}| = 1$

- $\hat{r}_{12}$ points from $q_1$ to $q_2$

Consider the vector eq'n

force on $q_2$ due to $q_1$

$$\boxed{\vec{F}_{12} = \frac{k_e q_1 q_2}{r^2} \hat{r}_{12}}$$

Vector eq'n for force on $q_2$ due to $q_1$.

Like charges (two pos. or two neg. charges)

$q_1 q_2 > 0$

In this case, $\vec{F}_{12}$ is parallel to $\hat{r}_{12}$ (in same dir'n as $\hat{r}_{12}$)

Opp. charges (one pos. & one neg).

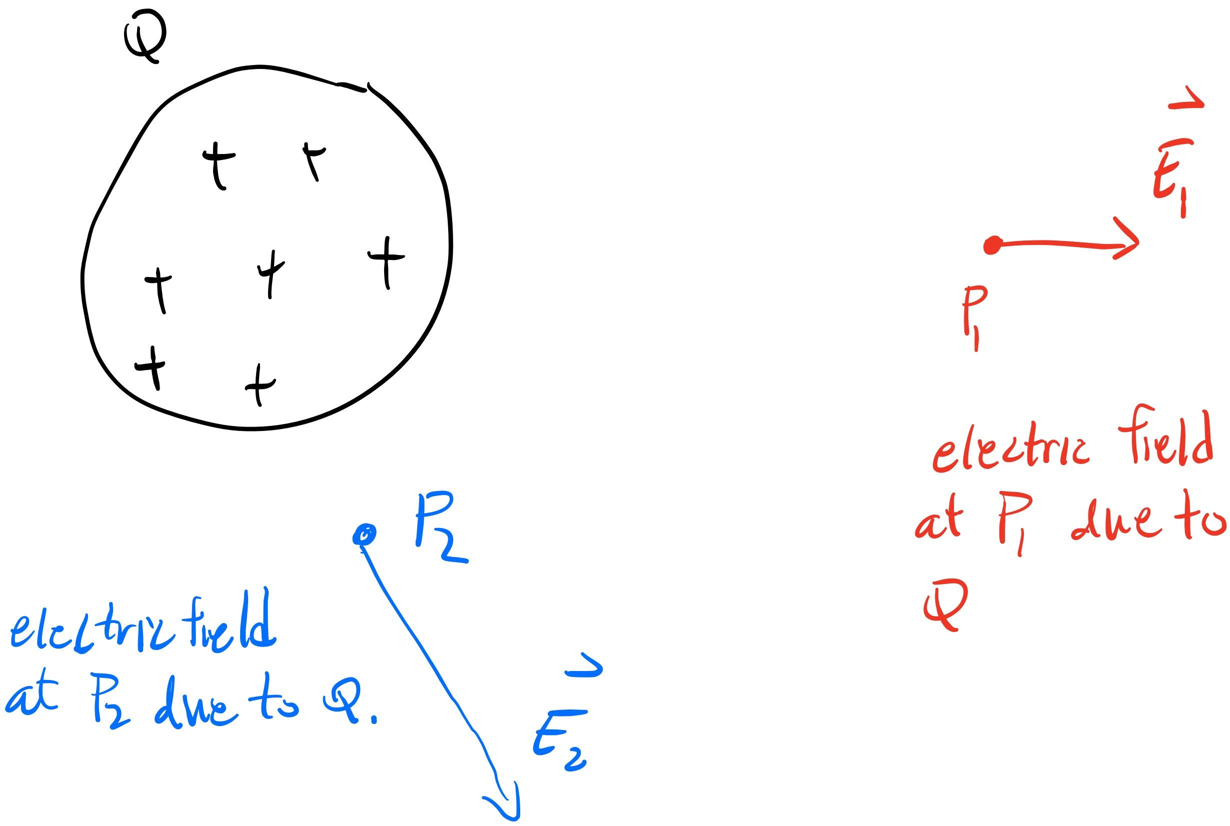
$q_1 q_2 < 0$

In this case, $\vec{F}_{12}$ is antiparallel to $\hat{r}_{12}$ (opp dir'n of $\hat{r}_{12}$).

5.4 in OSUPv2 The Electric Field

Use the symbol $\vec{E}$ for electric field.

A charged object generates an electric field that exerts forces on other charges.



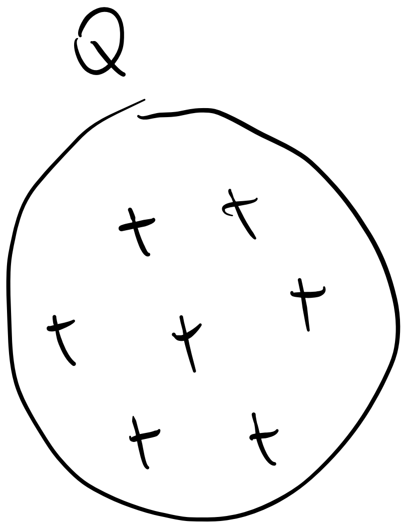

To determine the electric field at a pt due to Q, place a small "test charge" $q_0$ & meas. the force on it.

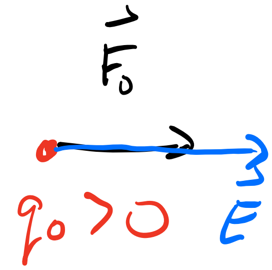
By definition, the force on $q_0$ due to Q is given by:

$$\vec{F}_0 = q_0 \vec{E}$$

Force on $q_0$ due to Q

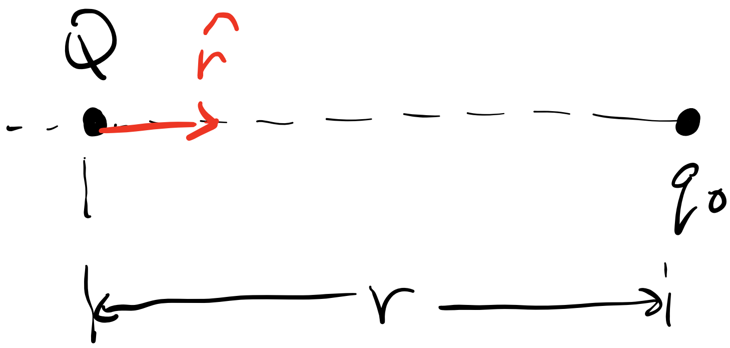
electric field due to Q.




$$\vec{E} = \frac{\vec{F}_0}{q_0} \qquad [\vec{E}] = \frac{[\vec{F}_0]}{[q_0]} = \frac{N}{C}$$

Electric due to a point charge Q.




Force on $q_0$ due to Q is:

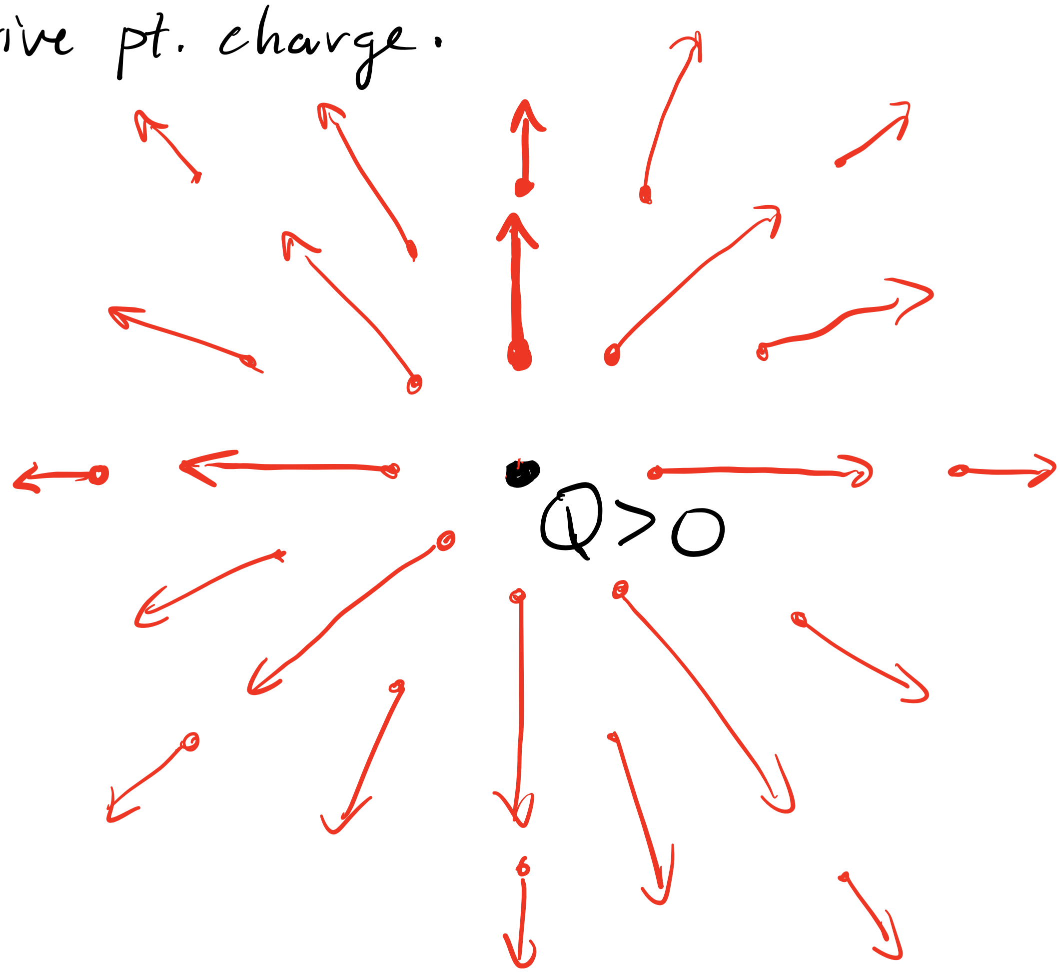
- $\vec{F}_0 = q_0 \vec{E}$
- $\vec{F}_0 = k_e \dfrac{q_0 Q}{r^2} \hat{r}$ (Coulomb's Law)

$$\cancel{q_0} \vec{E} = \frac{k_e \cancel{q_0} Q}{r^2} \hat{r}$$

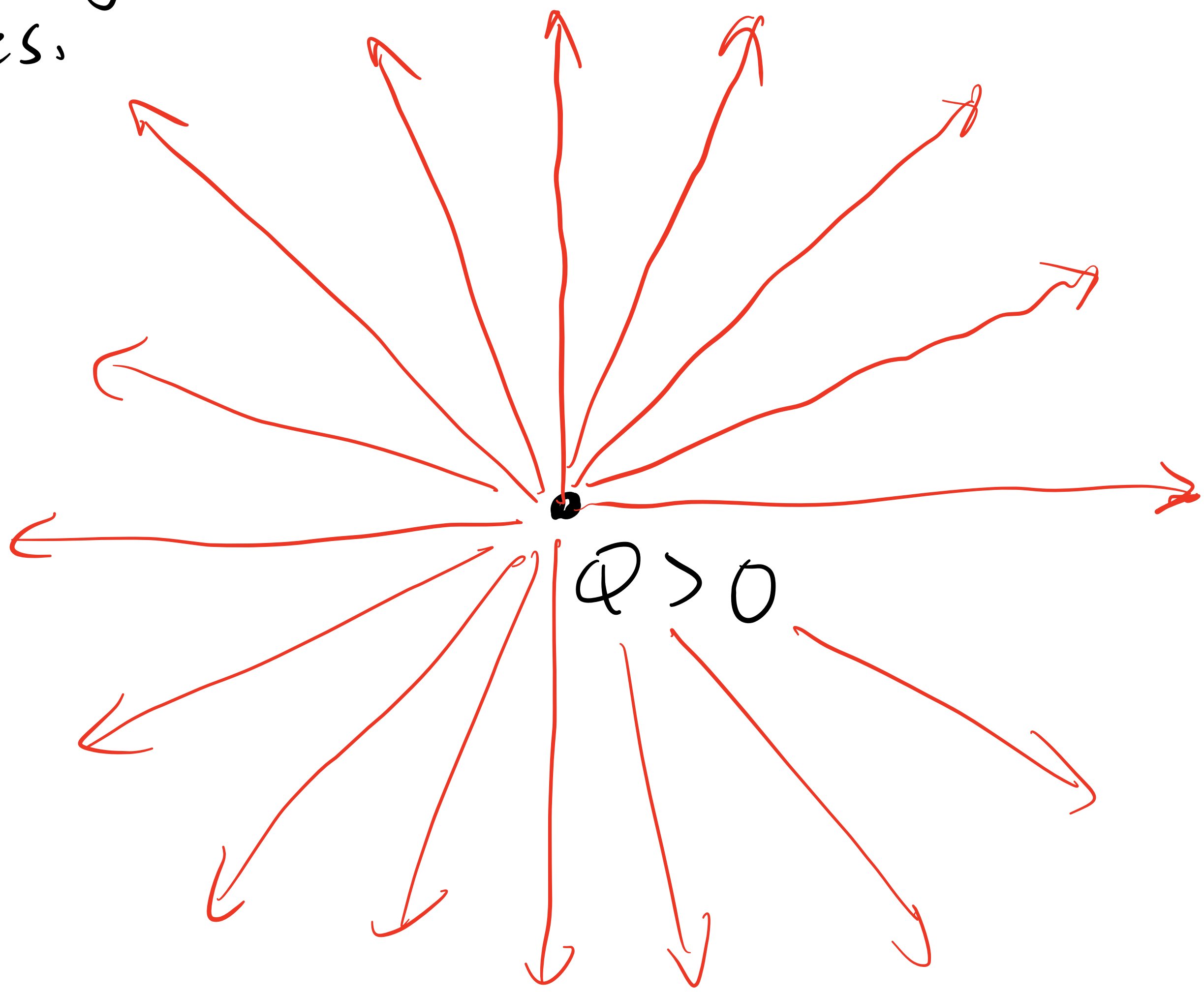
The electric field due to Q is given by:

$$\boxed{\vec{E} = \frac{k_e Q}{r^2} \hat{r}}$$ Electric of a pt. charge Q.

Try to map out the electric field of a positive pt. charge.

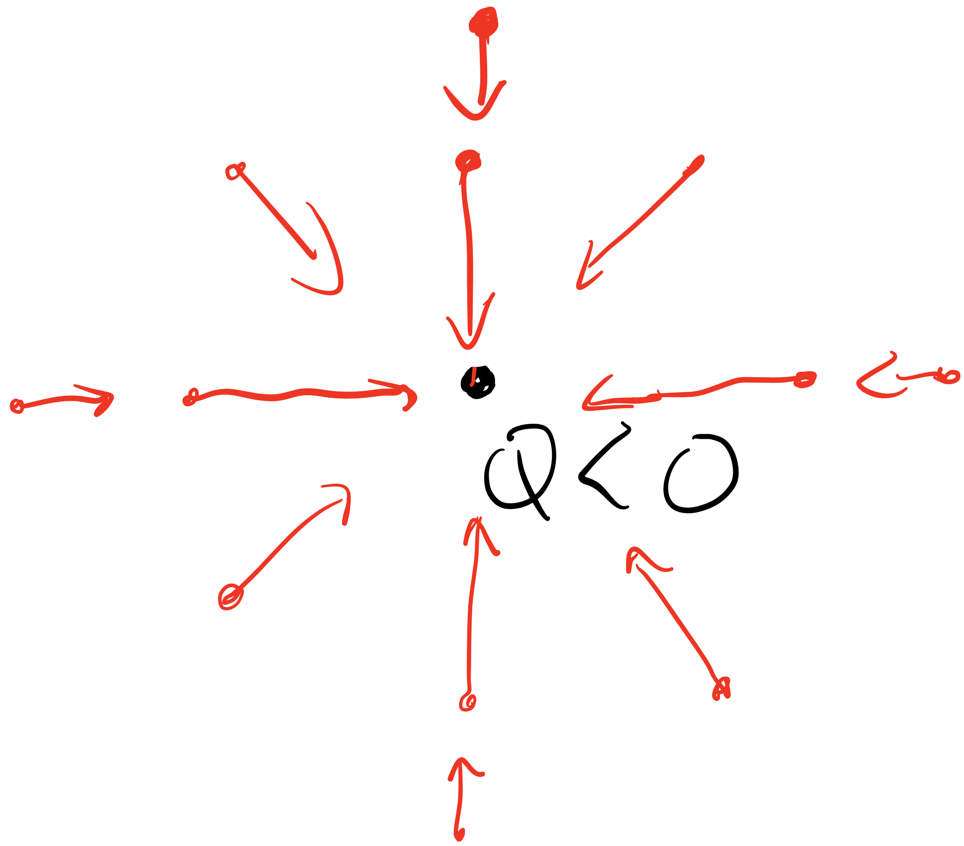


Usually draw $\vec{E}$-field lines as continuous lines.




In this picture the density (spacing) of $\vec{E}$-field lines tells the strength of the electric field. Where lines are closely spaced, $\vec{E}$ is strong. $\vec{E}$ is weak where lines are spaced further apart (low density).

Negative Point Charge. $\vec{E} = \frac{k_e Q}{r^2}\hat{r}$




$$\Downarrow$$