Electricity and Magnetism

- Physics 259 – L02
- Lecture 8

Sections 21.1-3

(please read chapter 21 of the textbook)

Last time

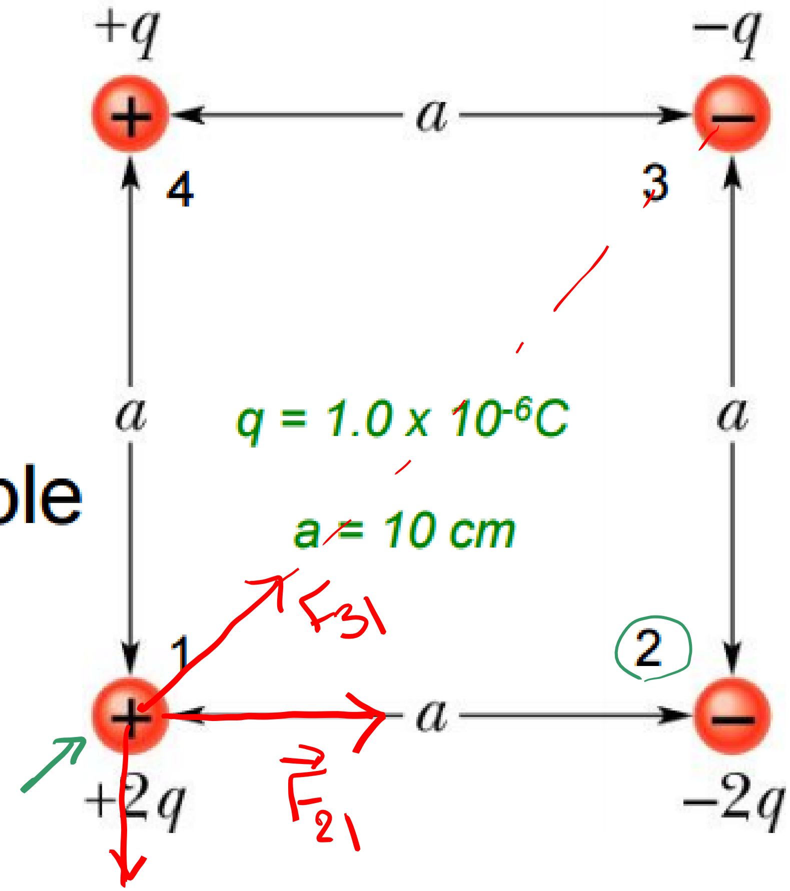
- Charges and Force Between Charges
- Conductors and Insulators
- Van De Graaff Generator Experiment 
- Solve Class Activity Question
- Coulomb’s Law
- Examples for superposition principle 
- Electric Ping Pong Experiment

This time

- Examples for Coulomb’s law
- Class Activity

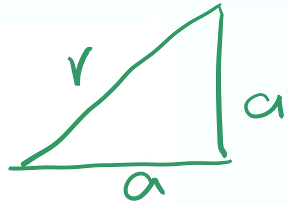
Calculate the net force on particle 1.

Use superposition principle



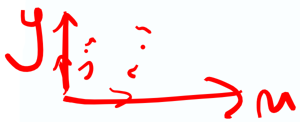
$$\vec{F}_{1,net} = \vec{F}_{2\ on\ 1} + \vec{F}_{3\ on\ 1} + \vec{F}_{4\ on\ 1}$$

$$\vec{F}_{3\ on\ 1} = k_e \frac{|q_1||q_3|}{r^2}\hat{r}_{31}$$



$r = \sqrt{a^2 + a^2}$

$= \sqrt{2a^2}$



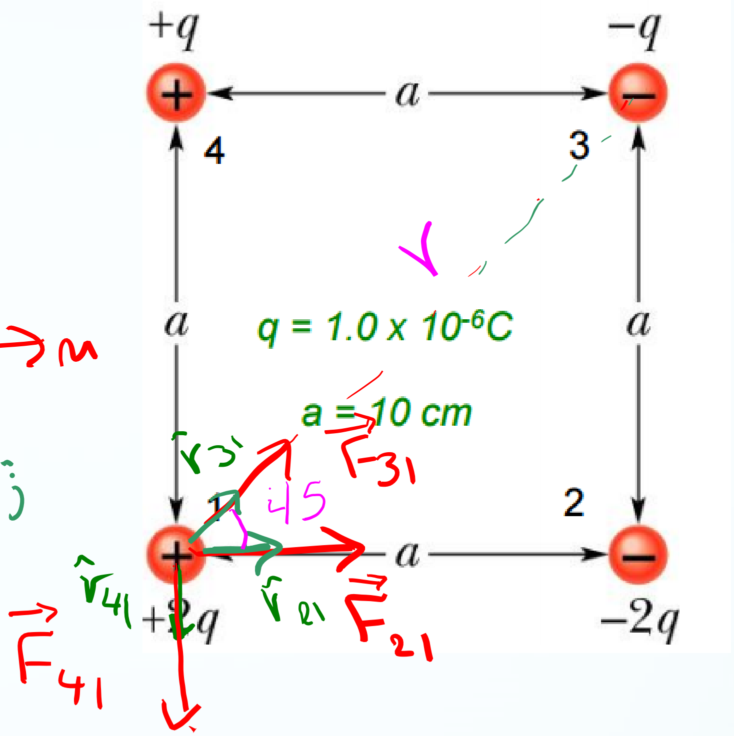
$$\vec{F}_{3\ on\ 1} = k_e \frac{|q_1||q_3|}{r^2}\hat{r}_{31}$$

$$= k_e \frac{(2q)(q)}{\left(\sqrt{2a^2}\right)^2}\hat{r}_{31}$$

$r = \sqrt{2a^2}$

$$= k_e \frac{\cancel{2}q^2}{\cancel{2}a^2}\hat{r}_{31} = k_e \frac{q^2}{a^2}\left(\cos 45\ \hat{i} + \sin 45\ \hat{j}\right)$$

$\hat{r} = \cos 45\ \hat{i} + \sin 45\ \hat{j}$



$$\vec{F}_{2\ on\ 1} = k_e \frac{|q_1||q_2|}{r^2}\hat{r}_{21}$$

$r = a$

$$\vec{F}_{2\ on\ 1} = k_e \frac{|q_1||q_2|}{r^2}\hat{r}_{21}$$

$$= k_e \frac{(2q)(2q)}{a^2}\hat{i}$$

$\hat{i}$ -> direction

$$= 4k_e \frac{q^2}{a^2}\hat{i}$$

$$\vec{F}_{4\ on\ 1} = k_e \frac{|q_1||q_4|}{r^2}\hat{r}_{41}$$

$r = a$

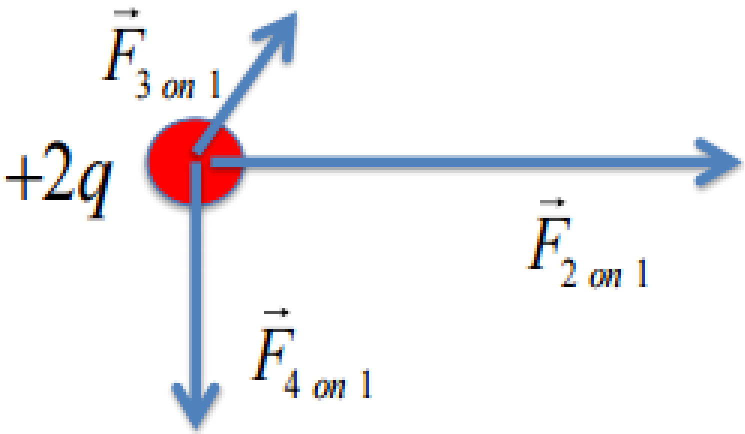
$$\vec{F}_{4\ on\ 1} = k_e \frac{|q_1||q_4|}{r^2}\hat{r}_{41}$$

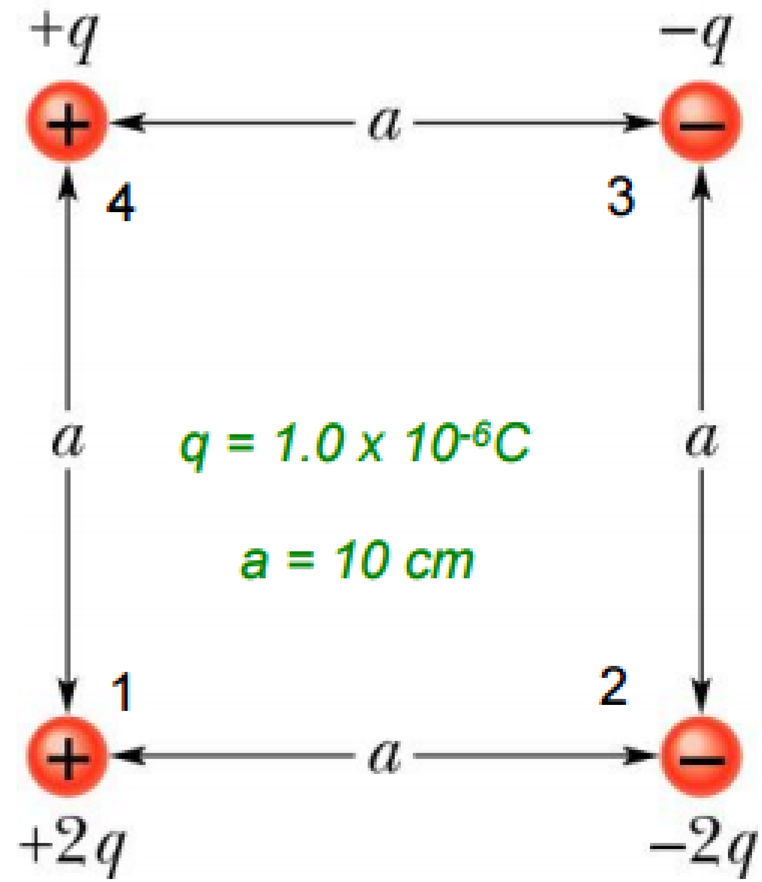
$$= k_e \frac{(2q)(q)}{a^2}\hat{r}_{41}$$

$$= 2k_e \frac{q^2}{a^2}\hat{r}_{41} = -2k_e \frac{q^2}{a^2}\hat{j}$$

-> $-\hat{j}$ direction

Putting it all together.



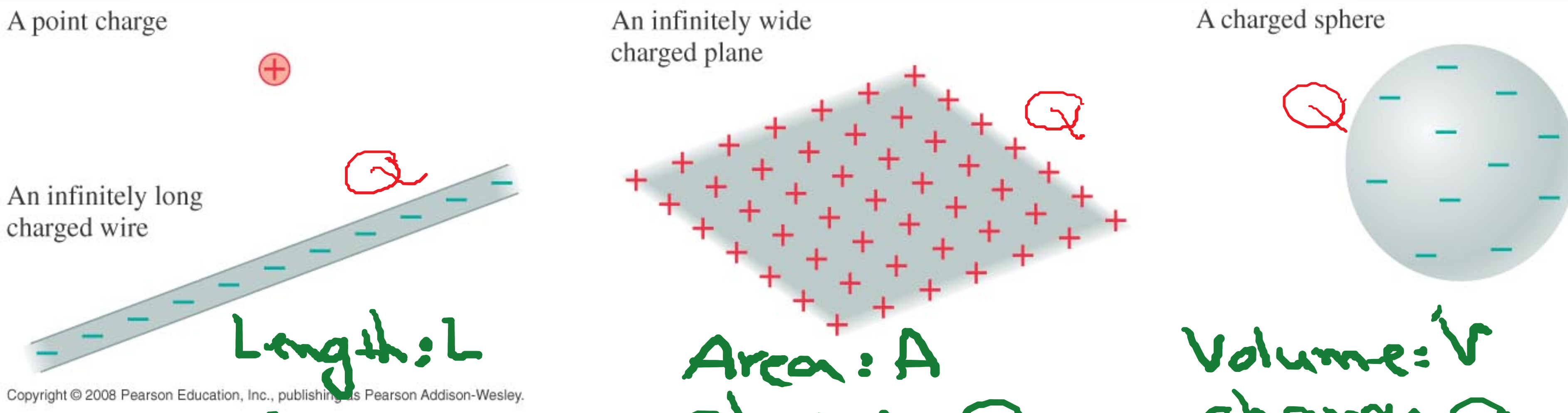


$$\vec{F}_{net\ on\ 1} = \vec{F}_{21} + \vec{F}_{31} + \vec{F}_{41}$$

$$\vec{F}_{on\ 1} = 4k_e \frac{q^2}{a^2}\hat{i} + k_e \frac{q^2}{a^2}\left(\cos 45\ \hat{i} + \sin 45\ \hat{j}\right) - 2k_e \frac{q^2}{a^2}\hat{j}$$

$$\vec{F}_{on\ 1} = k_e \frac{q^2}{a^2}\left[(4 + \cos 45)\ \hat{i} + (-2 + \sin 45)\ \hat{j}\right]$$

4 basic geometries



Length: L
Charge: Q

Area: A
charge: Q

Volume: V
charge Q

- These geometries are basic because they're very symmetrical

Linear, surface and volume charge densities

$$\lambda = \frac{Q}{L}$$

linear charge density

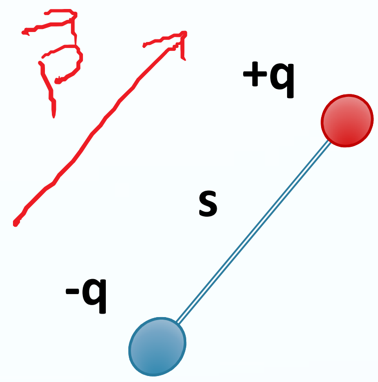
$$\sigma = \frac{Q}{A}$$

Surface charge density

$$\rho = \frac{Q}{V}$$

volume charge density

Electric dipole moment



distance between charges

$\vec{p} = (qs$, from the negative to positive charge)

charge of one of the charges

EM Force VS. Gravitational Force

electrostatic force

$$\vec{F} = k \frac{q_1 q_2}{r^2} \hat{r}$$

Coulomb's law

↓

both attractive and repulsive

gravitational force

$$\vec{F} = G \frac{m_1 m_2}{r^2} \hat{r}$$

Newton's law

↓

Just attractive

Charge quantization: $q = ne$, $n = \pm 1, \pm 2, \dots$

$e = 1.62 \times 10^{-19}\,C$ → charge of electron

Charge conservation:

electron

positron

annihilation → $e^- + e^+ \rightarrow \gamma + \gamma$ → gamma ray

pair production → $\gamma \rightarrow e^- + e^+$

Charge is conserved in both cases

This section we talked about:

Chapter 21.1-3

See you on Monday