Announcements

Today's class activity

Test the entire process (including marking) to make sure it runs smoothly.

The assignment will be graded, but not counted for marks (the activity has been assigned 0 weight on D2L).

Students will get feedback without their grades being affected.

Last time

- More on structure of matter and fundamental particles
- Mass and charge
- Transfer of charge
- Conductors and insulators
- Coulomb's law

This time

- Defining Coulomb force, magnitude and direction
- Unit vectors to show a given direction
- Practicing unit vectors
- 1^{st} class activity

What we know

- There are positive and negative charges
- Like charges repel each other
- Opposite charges attract each other
- The force between charged objects varies with distance
- The force between charged objects depends on the amount of charge

HOW CAN WE QUANTIFY THIS?

Charles Coulomb determined the electrostatic force law

- Coulomb's Law allows the calculation of electrostatic attraction or repulsion.

The **magnitude** of the electrostatic force:

$$F_e = k_e \frac{|q_1||q_2|}{r^2}$$

$$k_e = 8.99 \times 10^9 \ \mathrm{Nm}^2 / C^2$$

Charles Augustin de **Coulomb** (1736 -1806)

How is the force oriented?

The force acts along the line connecting the charges.

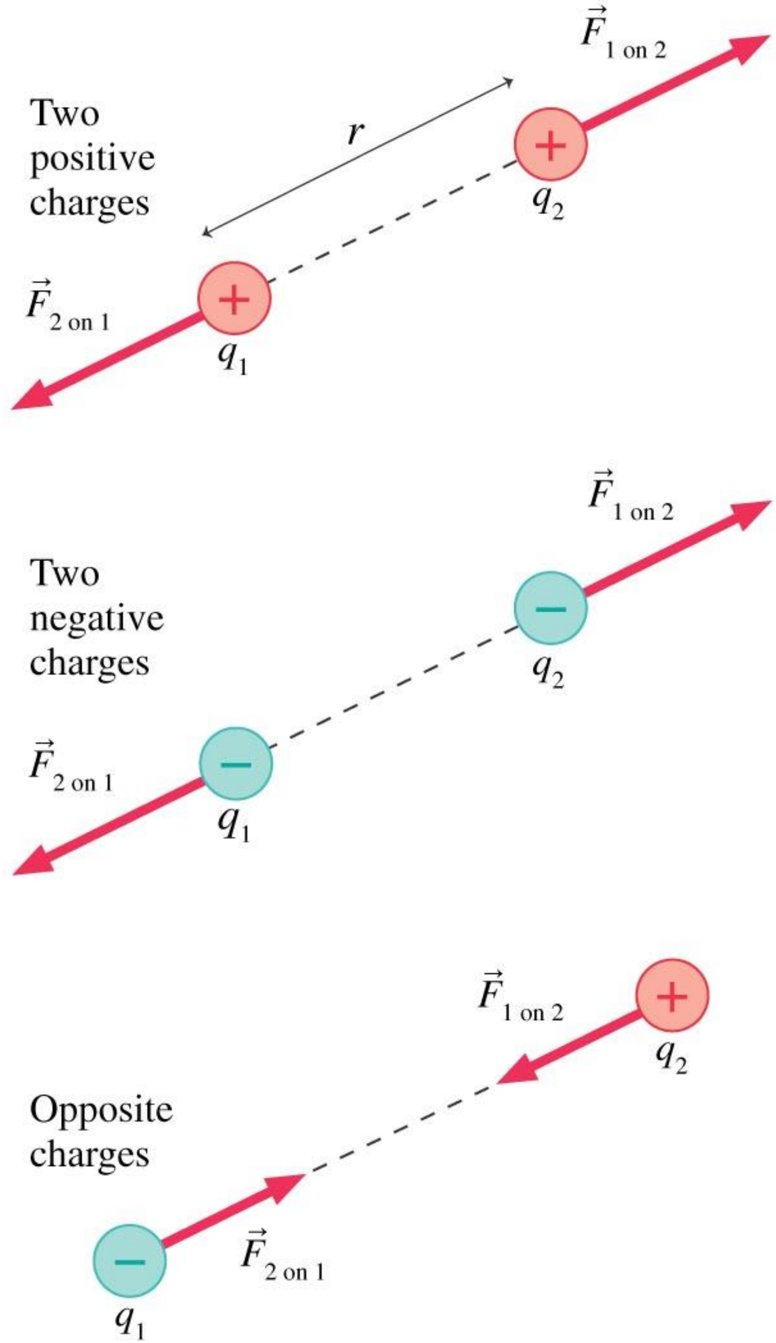
Coulomb's Law

There are only two kinds of charges:

positive and **negative**.

Charges of the **same** sign **repel** each other.

Charges of **opposite** sign **attract** each other.



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Coulomb's Law

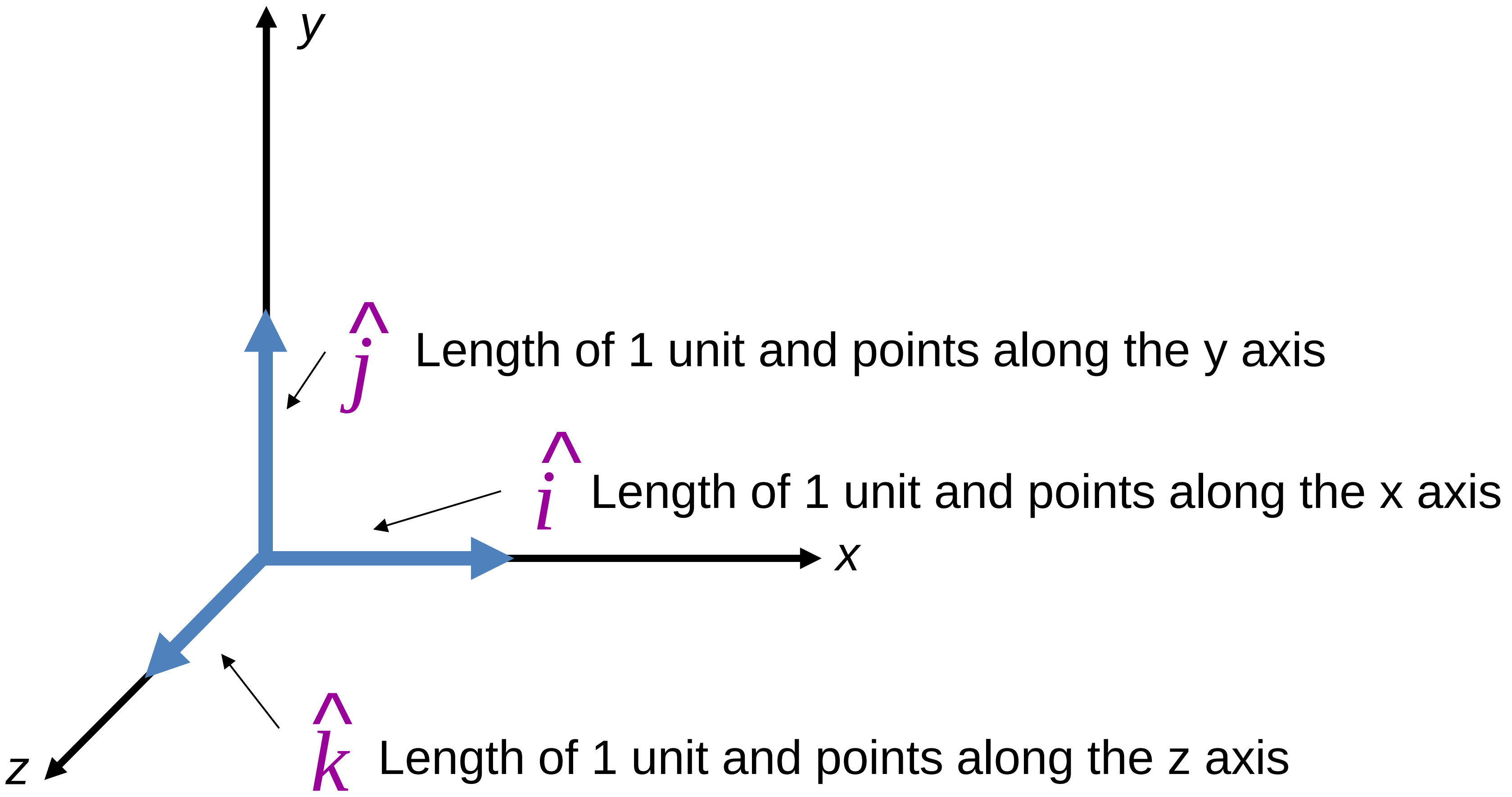
Force is a vector quantity.

We need to define its magnitude and its direction.

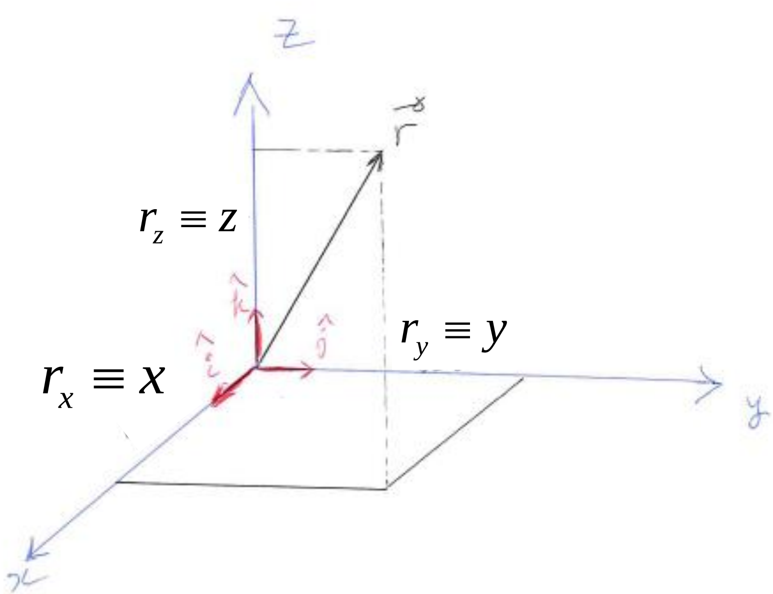
$$\vec{F}_e = k_e \frac{q_1 q_2}{r^2} \hat{r}$$

$\hat{r}$ is a unit vector (magnitude of one or unity) showing the direction of the force and is dimensionless.

Unit vectors and three dimensional space



Representing a vector in three dimensions



$$\vec{r} = r_x\hat{i} + r_y\hat{j} + r_z\hat{k}$$

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

Magnitude

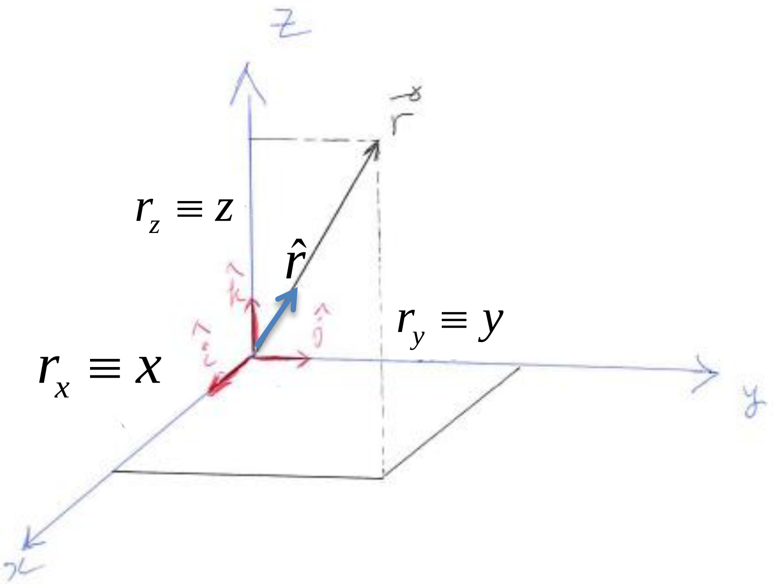
$$|\vec{r}| \equiv r = \sqrt{x^2 + y^2 + z^2}$$

$$\hat{r} = \frac{\vec{r}}{r} = \frac{x}{r}\hat{i} + \frac{y}{r}\hat{j} + \frac{z}{r}\hat{k}$$

Unit vector

$$\hat{r} = \frac{\vec{r}}{r} = \frac{x}{r}\hat{i} + \frac{y}{r}\hat{j} + \frac{z}{r}\hat{k}$$

$$r = \sqrt{x^2 + y^2 + z^2}$$



$$\hat{r} = \frac{x}{\sqrt{x^2 + y^2 + z^2}}\hat{i} + \frac{y}{\sqrt{x^2 + y^2 + z^2}}\hat{j} + \frac{z}{\sqrt{x^2 + y^2 + z^2}}\hat{k}$$

$\hat{r}$ is dimensionless with unit magnitude.

Example

$$\vec{r} = r_x\hat{i} + r_y\hat{j} + r_z\hat{k}$$

$$\text{Let } r_x \equiv x = 3, r_y \equiv y = 4, r_z \equiv z = 5$$

$$\vec{r} = 3\hat{i} + 4\hat{j} + 5\hat{k}$$

$$r = \sqrt{x^2 + y^2 + z^2} = \sqrt{3^2 + 4^2 + 5^2} = \sqrt{50}$$

$$\hat{r} = \frac{3}{\sqrt{50}}\hat{i} + \frac{4}{\sqrt{50}}\hat{j} + \frac{5}{\sqrt{50}}\hat{k}$$