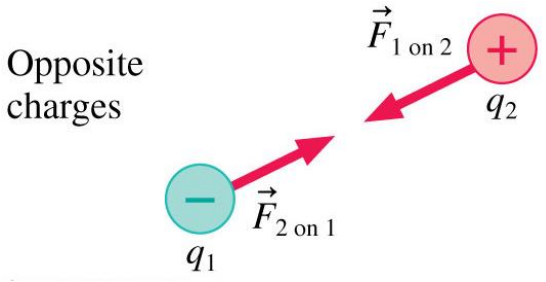
PHYSICS 12200
Electric Field

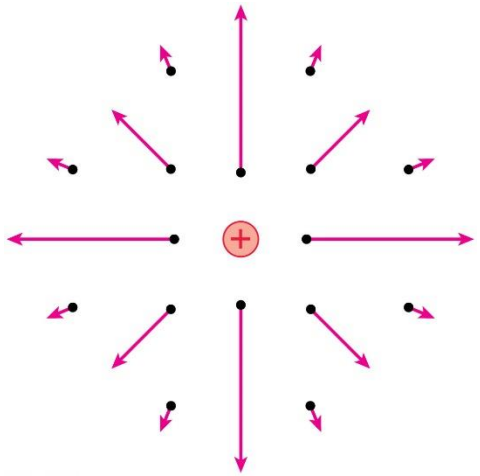
Electric Field…



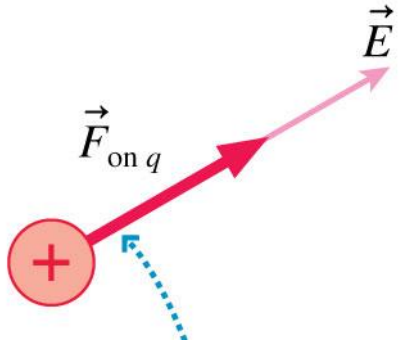
- The electric force is a **non-contact force**
  - Spooky action at a distance
- The concept of the field was developed to act as a mediator of force
- Examples
  - Gravitational Field (g)
  - Electric and Magnetic Fields

The Basic Model

An electrically charged object creates an electric field in the space around it



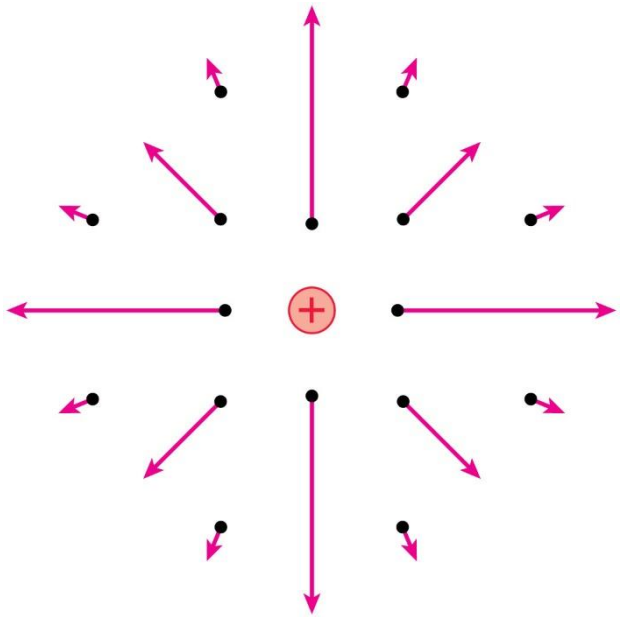
Electric Fields apply a force on other electrically charged objects



Electric Field…

The Basic Model continued

- A **field** is a function that assigns a quantity at each point in space.
- Example:
  - The temperature in a room is a scalar field
  - The gravitational field is a vector field
- The electric field is a vector field



Definition:

The **electric field** at a point in space (x, y, z) is the electric force per unit charge on a test charge (probe charge) located at that point.

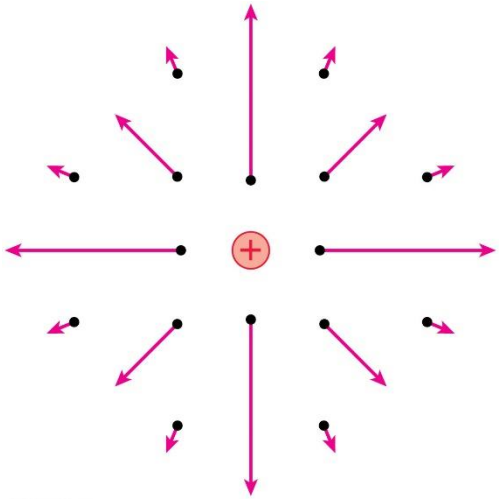
$$\vec{E}(x,y,z) \equiv \frac{\vec{F}_{on\ q_0}}{q_0}$$

- A test charge (q_0) is a small **positive** charge
- So small that its own electric field is negligible
- It only serves to probe the electric effects of other charges
- The **SI unit** of electric field is: N/C.

Electric Field

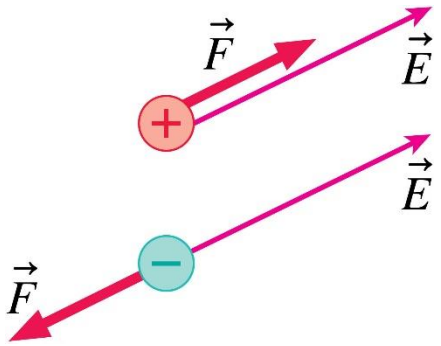
Electric Field Basic Facts

E is in the direction of the force on a positive charge.



The force on a charge in an electric field is

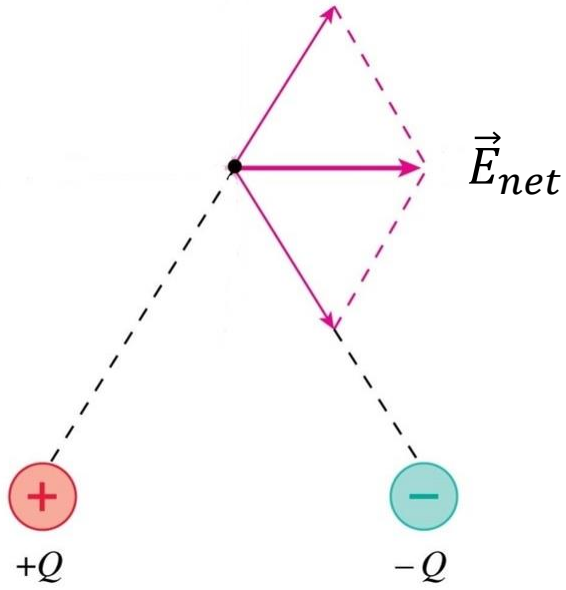
$$\vec{F} = q\vec{E}$$



Superposition:

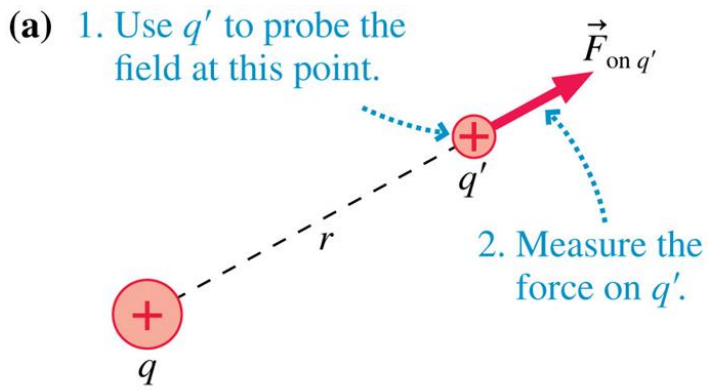
- Suppose the source of an electric field is a group of point charges q_1, q_2, …
- The net electric field $\boldsymbol{E}_{\text{net}}$ is the vector sum of the electric fields due to each charge.

$$\vec{E}_{net} = \sum \vec{E}_i$$



The Electric Field of a Point Charge…

- Consider a point charge q and a test charge q'



- Apply Coulomb's law:

$$\vec{F} \equiv \frac{1}{4\pi\varepsilon_0}\frac{q \cdot q'}{r^2}\hat{r}$$

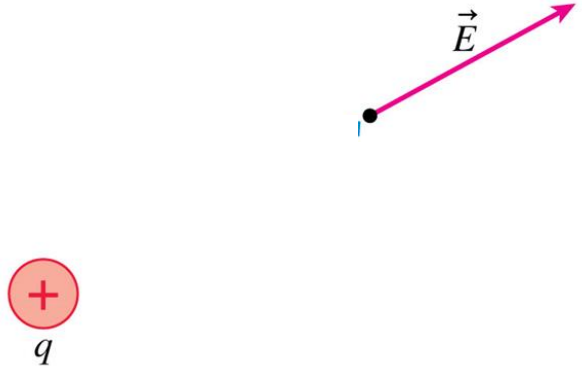
- Where $\hat{r}$ is a unit vector that points radially away from the source charge q.

From the definition of electric field:

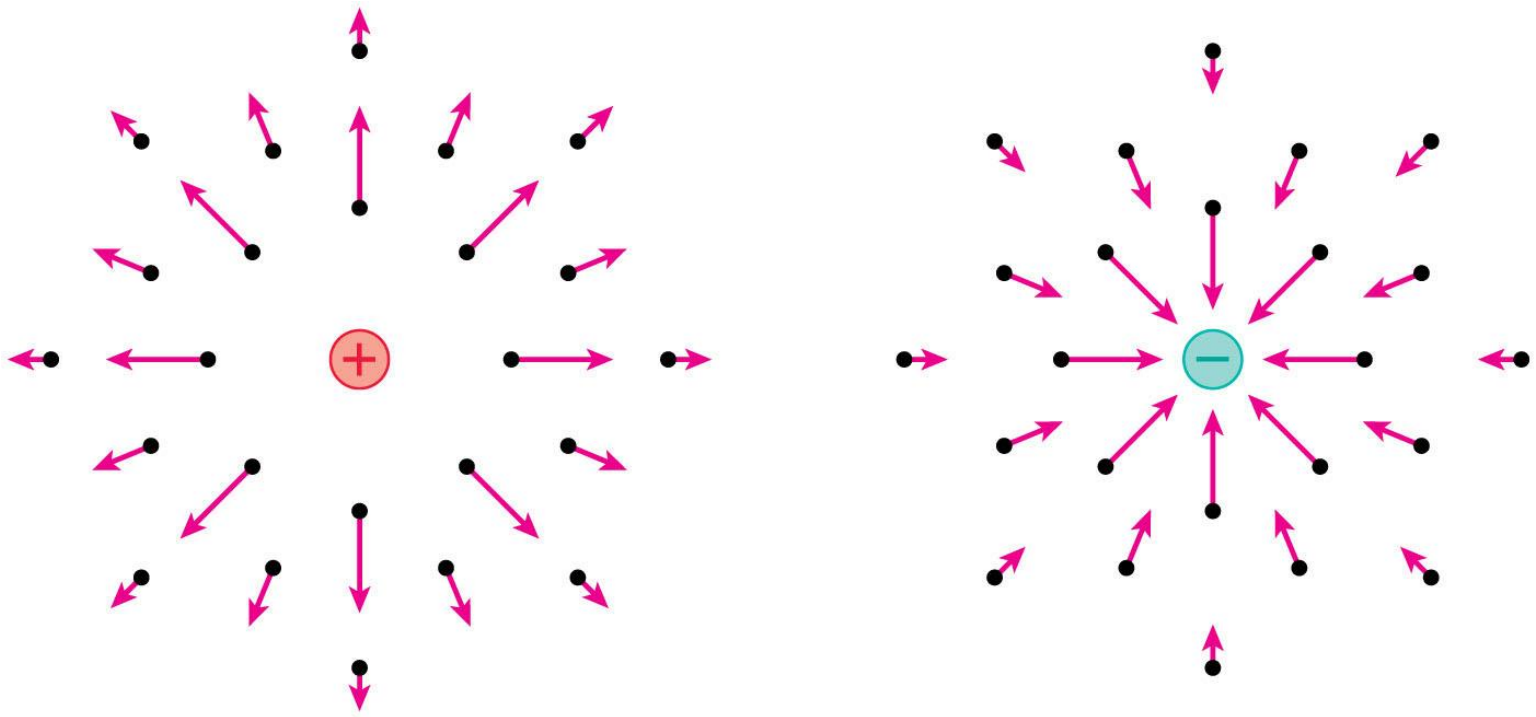
$$\vec{E} \equiv \frac{\vec{F}}{q'}$$

$$\Downarrow$$

$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}}$$



The Electric Field of a Point Charge



$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

Example: Knight Problem 22.30

What are the strength and direction of an electric field that will balance the weight of a 1.0 g plastic sphere that has been charged to -3.0 nC?

Know: $m = 1.0$ g, $q = -3.0$ nC Find: $\vec{E}$

Solution

We need: $F_E = F_G \implies |q|E = mg \;\therefore\; E = \dfrac{mg}{|q|} \;\therefore\; E = \dfrac{(1.0 \times 10^{-3}\text{kg})(9.8\ \text{m/s}^2)}{3.0 \times 10^{-9}\text{C}} = 3.3 \times 10^{6}\ \text{N/C}$

Direction

- The force needs to point upward to balance the downward force of gravity
- Because the charge is negative, the direction of the electric field is opposite of the force