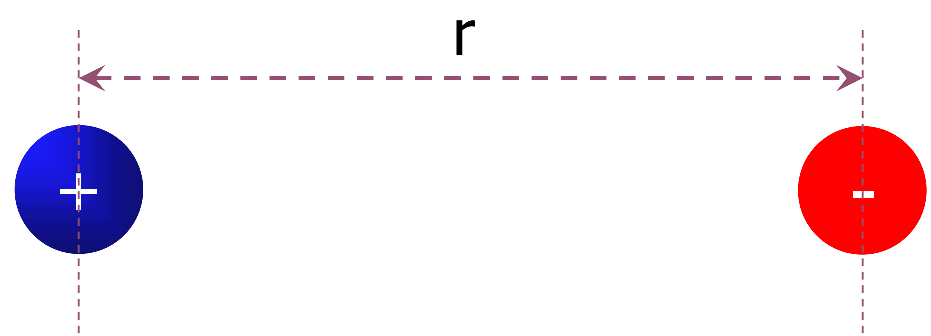
Lecture 3: Electric field

Force between charges:

Coulomb's Law

$$F = k\frac{|\,q_1 q_2\,|}{r^2}$$



Like charges repel
Unlike charges attract

k = 9 x 10^9 N•m^2/C^2

Concept of electric field

Charged particles exert forces over a distance.
How?
Charged particle “sends out” an electric field into space, other charged particles feel the presence of the field by feeling a force.

$$\vec{E}\ \text{at}\ (\text{xyz}) = \frac{\vec{F}\, on\ q\ at\ (xyz)}{q}$$

Electric field or electric field strength. Unit: N/C

Electric field is a vector, exists at every point in space

If q is positive: $\vec{E}$ points in the same direction as $\vec{F}$ on charge

If q is negative: $\vec{E}$ points in the opposite direction as $\vec{F}$ on charge

Field does not depend on the size of the probe charge

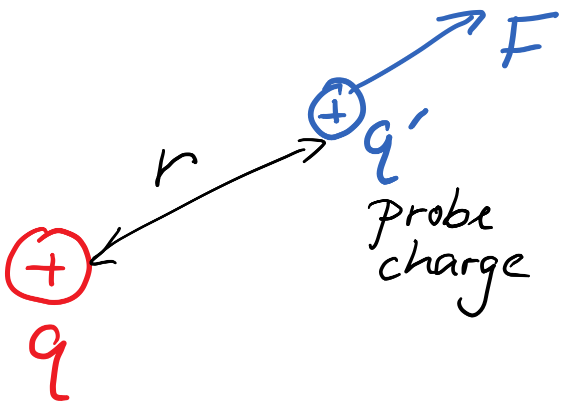
If the electric field is given, we can find the force on q:

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

Electric field of a point charge

$$\vec{E} = \frac{\vec{F}\, on\, q'}{q'}$$

$$F_{on\, q'} = k\frac{|qq'|}{r^2}$$



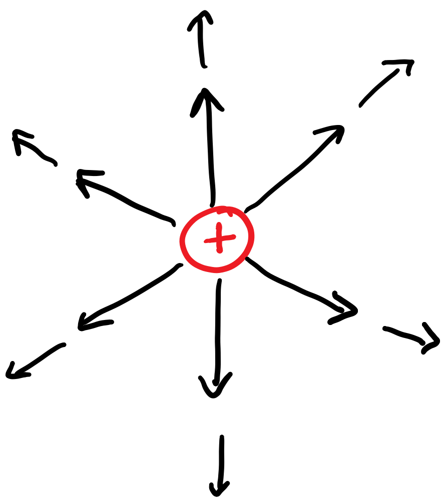
If q is negative, force on q' is towards q, field towards q

$$\vec{E} = \frac{k|q|}{r^2},$$

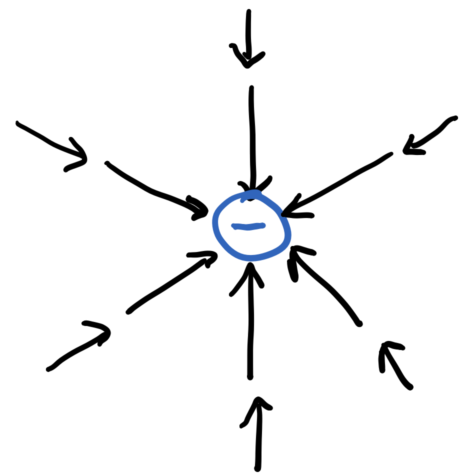
away from q for q>0
towards q for q<0

Visualization

$$\vec{E} = \frac{k|q|}{r^2}$$

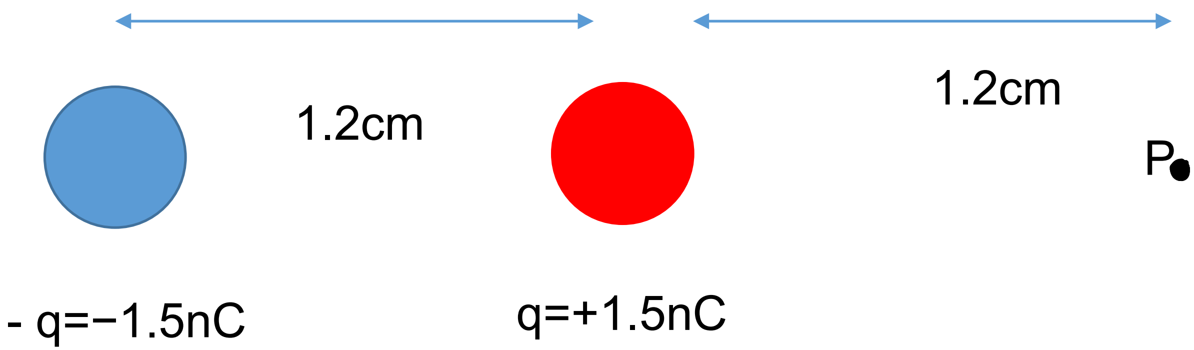


away from +



towards −

Example: Field of a dipole

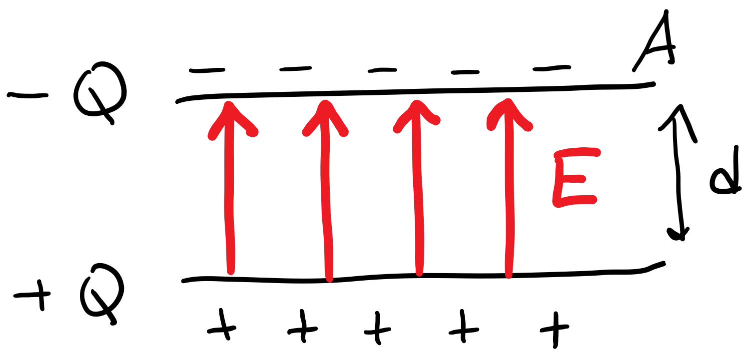


Dipole: pair of charges with equal charge magnitude, opposite signs

Net field at point P?

Uniform electric field

Large parallel plates (size >> separation) of area A



Horizontal components cancel,
only vertical components remain
Field inside parallel plate capacitor
is constant
A area of plate,
Q charge on one plate
Q/A =σ surface charge density

$$\vec{E} = \frac{Q}{\varepsilon_o A}, \text{ from + to −}$$

$$\varepsilon_o = \frac{1}{4\pi k} = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$$

Permittivity constant