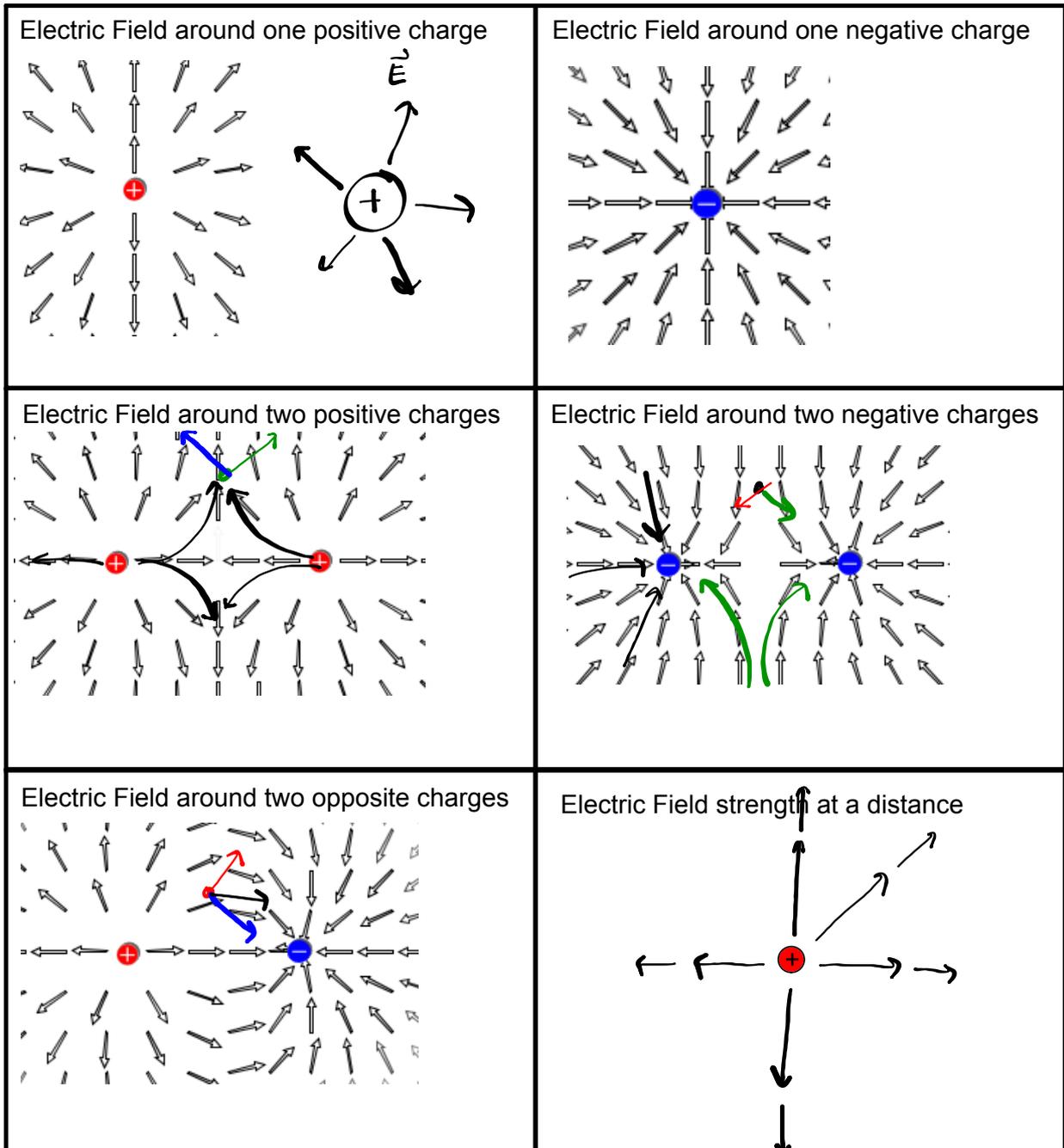


L05 - Electric Fields

Electric Field: An **area of influence** around an electric charge. This is a vector quantity (magnitude and direction).

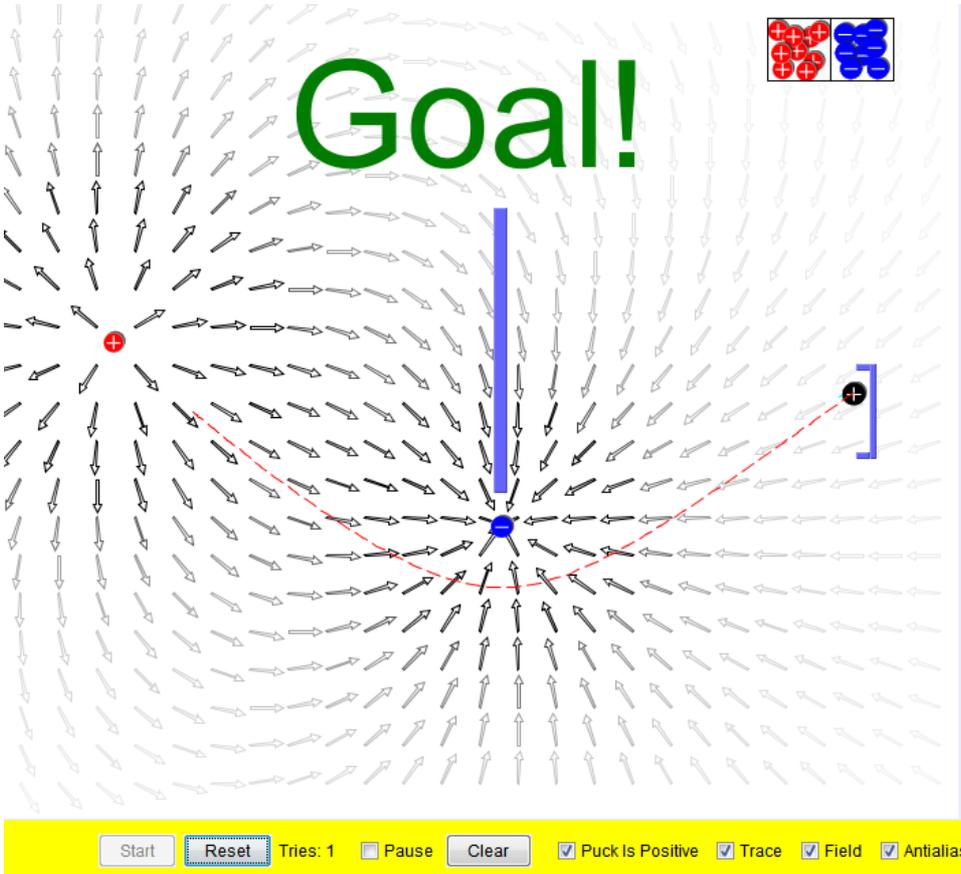
Electric Field Lines: Lines drawn to represent the electric field; density of the lines represents the magnitude of the electric field.

<http://phet.colorado.edu/en/simulation/electric-hockey>

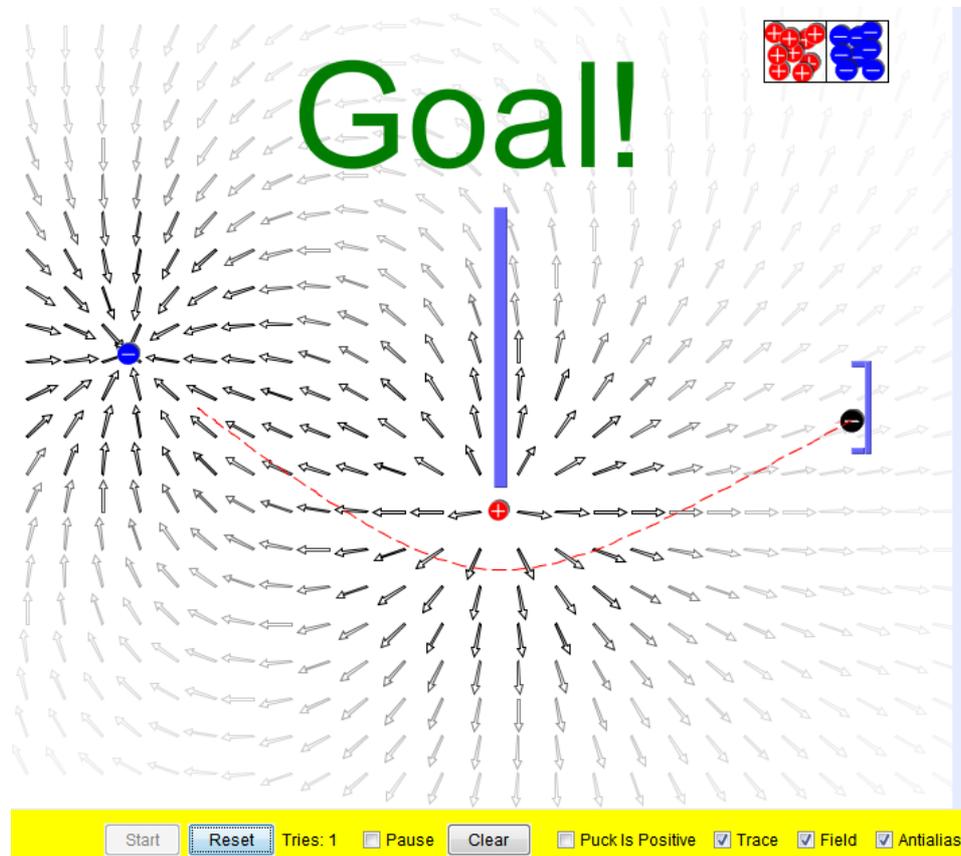


Electric Fields - "Areas of Influence"

The electric field lines indicate the direction a **POSITIVE** charge would feel force.

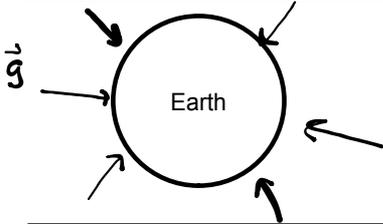
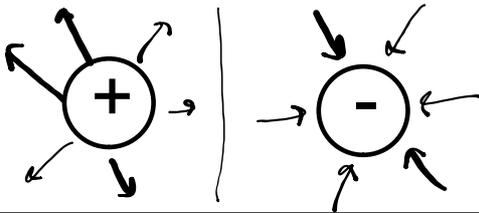


This screenshot shows an electric field simulation. A red '+' sign is on the left, and a blue '-' sign is on the right. A blue vertical bar is in the center. A red dashed line traces a path from the blue '-' sign towards the red '+' sign. The word "Goal!" is written in green. A control bar at the bottom has buttons for Start, Reset, Tries: 1, Pause, Clear, and checkboxes for Puck Is Positive, Trace, Field, and Antialias.

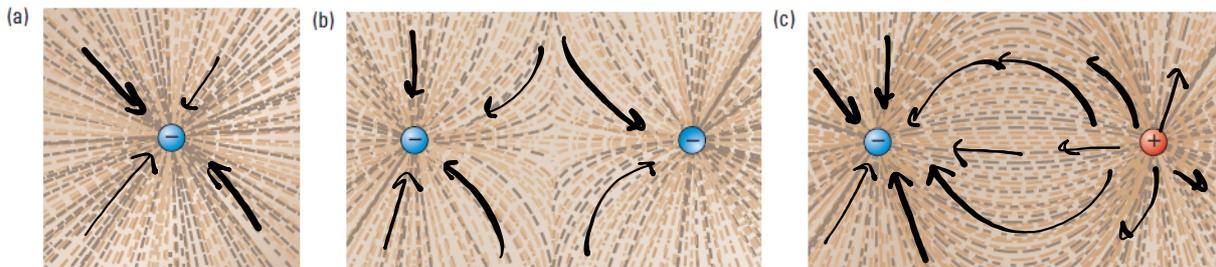


This screenshot shows the same electric field simulation but with the red '+' sign on the right and the blue '-' sign on the left. The red dashed line traces a path from the blue '-' sign towards the red '+' sign. The word "Goal!" is written in green. A control bar at the bottom has buttons for Start, Reset, Tries: 1, Pause, Clear, and checkboxes for Puck Is Positive, Trace, Field, and Antialias.

Gravitational fields Vs Electric fields

| Gravitational Force | | Electrostatic Force |
|---|--------------------------|--|
| Direction a MASS would feel a force. | Direction | Direction a POSITIVE TEST CHARGE would feel a force |
|  | Diagram |  |
| $ \vec{g} = \frac{Gm_{source}}{r^2}$ | Source Mass / Charge | $ \vec{E} = \frac{kq_{source}}{r^2}$ |
| $\vec{F}_g = m\vec{g}$ $\vec{g} = \frac{\vec{F}_g}{m}$ | Test Charge Test Mass | $\vec{E} = \frac{\vec{F}_e}{q}$ $\vec{F}_e = q\vec{E}$ |
| N/kg | Units | N/C |

Q1: What direction would the field lines be?



Gravity

$$F_g = \frac{Gm_{source}m_{test}}{r^2}$$

$$F_g = \vec{g}m_{test}$$

$$F_g = m\vec{g}$$

$$\vec{g} = \frac{F_g}{m}$$

Sheet

Electric Fields

$$F_e = \frac{kq_{source}q_{test}}{r^2}$$

On sheet

$$\vec{F}_e = \vec{E}q_{test}$$

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

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

Sheet

Q2: A sphere with a negative charge of $2.10 \mu\text{C}$ experiences a **force of repulsion** of $5.60 \times 10^{-2} \text{ N}$ when placed a certain distance from the source charge. What is the strength of the electric field at this point? Draw a diagram to represent the field lines at this point.

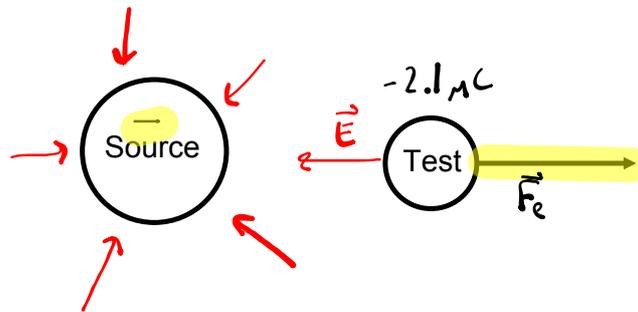
$$|\vec{E}| = \frac{\vec{F}_e}{q_{\text{test}}}$$

$$|\vec{E}| = \frac{5.60 \times 10^{-2} \text{ N}}{2.1 \times 10^{-6} \text{ C}}$$

$$= 2.6 \times 10^4 \text{ N/C}$$

$$a.b_c \times 10^d \text{ N/C}$$

| | | | |
|---|---|---|---|
| 2 | 6 | 7 | 4 |
|---|---|---|---|



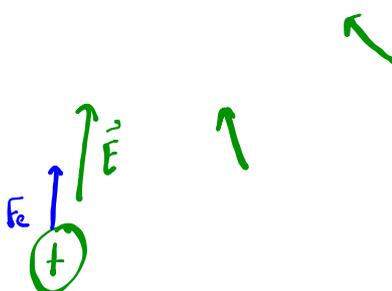
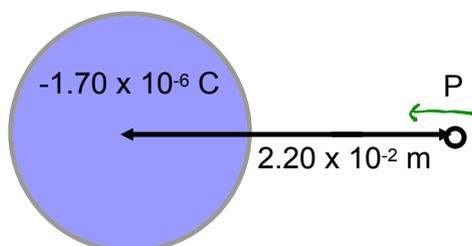
Q3: Determine the electric field at a position P that is $2.20 \times 10^{-2} \text{ m}$ from the center of a negative charge of $1.70 \times 10^{-6} \text{ C}$.

$$|\vec{E}| = \frac{kq_{\text{source}}}{r^2}$$

$$= \frac{(8.99 \times 10^9)(1.70 \times 10^{-6})}{(2.20 \times 10^{-2})^2}$$

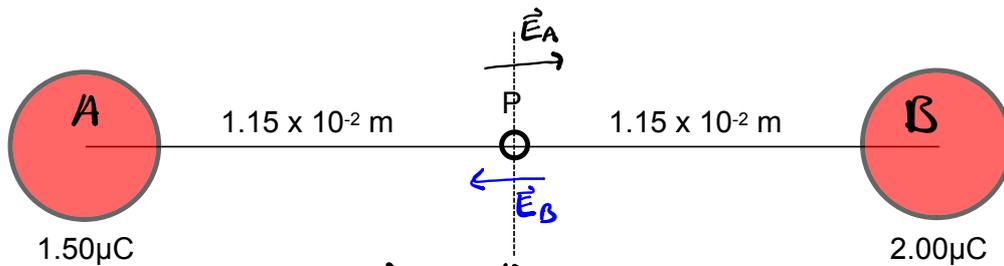
$$= \frac{15283}{0.000484}$$

$$|\vec{E}| = 3.16 \times 10^7 \text{ N/C}$$



Electric field is a Vector - Vectors Add!

Q4: Two positively charged spheres, A and B, with charges of $1.50\mu\text{C}$ and $2.00\mu\text{C}$ respectively, are $3.30 \times 10^{-2} \text{ m}$ apart. Determine the net electric field at the midway point.



$$|\vec{E}_A| = \frac{kq_A}{r^2} = \frac{(8.99 \times 10^9)(1.5 \times 10^{-6})}{(1.15 \times 10^{-2})^2}$$

$$= \frac{13485}{0.00013225}$$

$$= 1.01965973 \times 10^8 \text{ N/C}$$

$$|\vec{E}_B| = \frac{kq_B}{r^2} = \frac{(8.99 \times 10^9)(2 \times 10^{-6})}{(1.15 \times 10^{-2})^2}$$

$$= \frac{17980}{0.00013225}$$

$$= 1.35954631 \times 10^8 \text{ N/C}$$

$$\vec{E}_{\text{net}} = \vec{E}_A + \vec{E}_B$$

$$= 1.0196... \times 10^8 \text{ (R)} - 1.3595... \times 10^8 \text{ (R)}$$

$$= -3.3988657 \times 10^7 \text{ N/C (R)}$$

$$\approx -3.40 \times 10^7 \text{ N/C (L)}$$