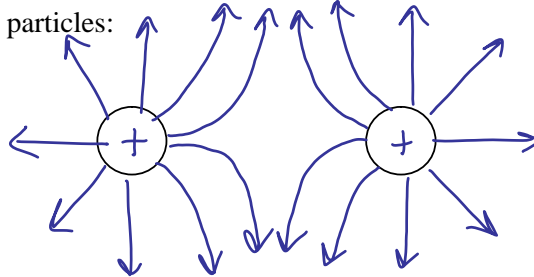


Electrostatics Notes

3 – Electric Field from Multiple Charges

We have already seen how charged particles emit electric fields, but how do these fields interact when two or more charges act on each other?

Consider two positively charged particles:

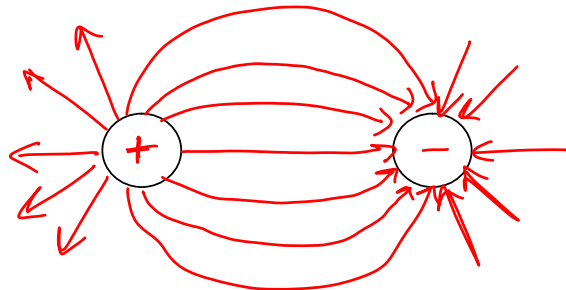


Note that the electric lines of force work... *in opposition to each other.*

Because this electric field is a force field, it is a vector. So when multiple fields overlap we simply... *add them up as vectors.*

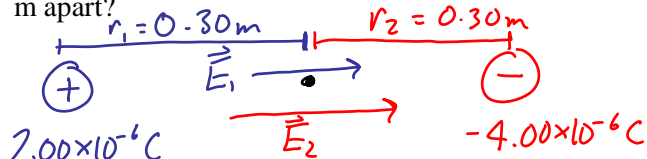
OK, now try two opposite charges:

Again the two fields interact, only this time they... *reinforce each other*



Example:

What is the strength of an electric field midway between a $2.00 \mu\text{C}$ charge and a $-4.00 \mu\text{C}$ that are 0.60 m apart?



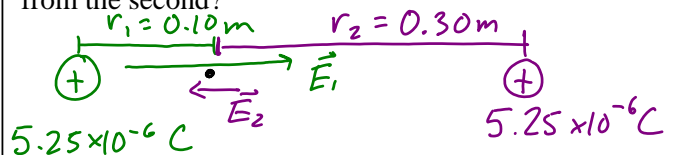
$$\vec{E}_1 = \frac{kq_1}{r_1^2} = 200\,000 \text{ N/C}$$

$$\vec{E}_2 = \frac{kq_2}{r_2^2} = 400\,000 \text{ N/C} \quad \text{* Note that we don't use the "-" sign for the charge}$$

$$\vec{E}_T = \vec{E}_1 + \vec{E}_2 = 600\,000 \text{ N/C}$$

Example:

Two $5.25 \mu\text{C}$ charges are 0.40 m apart. What is the strength of the electric field between them at a point 0.10 m away from the first charge and 0.30 m away from the second?



$$\vec{E}_1 = \frac{kq_1}{r_1^2} = 4\,725\,000 \text{ N/C}$$

$$\vec{E}_2 = \frac{kq_2}{r_2^2} = 525\,000 \text{ N/C}$$

$$\vec{E}_T = \vec{E}_1 - \vec{E}_2 = 4.20 \times 10^6 \text{ N/C}$$

Example:

Find the magnitude and direction of the electric field at the point P due to the charges as shown.

The diagram shows two point charges, q_1 and q_2 , and a point P. Charge q_1 is $12.0 \mu\text{C}$ and is located 6.0 m vertically above point P. Charge q_2 is $-8.0 \mu\text{C}$ and is located 4.5 m horizontally to the right of point P. A right-angle symbol is shown at point P, indicating that the line segments from the charges to P are perpendicular. The electric field vectors are shown as follows: \vec{E}_1 is a blue arrow pointing vertically downwards from P; \vec{E}_2 is a red arrow pointing horizontally to the right from P; and \vec{E}_T is a dashed black arrow representing the resultant electric field, pointing into the first quadrant. The angle θ is measured between \vec{E}_1 and \vec{E}_T .

Calculations for the electric field magnitudes:

$$\vec{E}_1 = \frac{kq_1}{r_1^2} = 3000 \text{ N/C}$$
$$\vec{E}_2 = \frac{kq_2}{r_2^2} = 3556 \text{ N/C}$$

Calculation for the resultant electric field magnitude:

$$\vec{E}_T = \sqrt{\vec{E}_1^2 + \vec{E}_2^2} = \boxed{4650 \text{ N/C}}$$

Calculation for the direction angle θ :

$$\tan \theta = \frac{\vec{E}_2}{\vec{E}_1}$$
$$\theta = \tan^{-1}\left(\frac{\vec{E}_2}{\vec{E}_1}\right) = \tan^{-1}\left(\frac{3556}{3000}\right) = \boxed{50^\circ}$$