Physics 30
Electric Forces & Fields

Jad Chehimi

May 4, 2021

Unfinished!

Contents

Electric Fields

Micheal Faraday

- Developed the idea of "lines of force" to describe electric fields
- A field is a "sphere of influence" in which a force can affect an object at a distance without contact
- There are electric, gravitational, and magnetic fields
- The symbol for electric field is $|\vec{E}|$

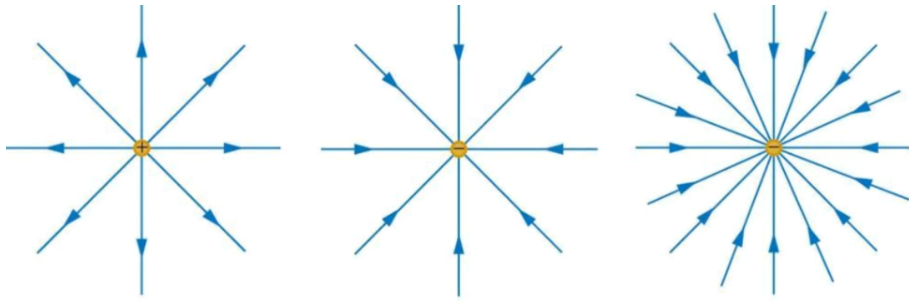
Gravitational Fields

$$\vec{g} = 9.81\,\frac{\mathrm{m}}{\mathrm{s}^2}$$

$$\vec{g} = \frac{Gm}{r^2}$$

- G = gravitational constant ($6.67 \cdot 10^{-11}\,\mathrm{N} \cdot \mathrm{m}^2/\mathrm{kg}^2$)
- m = mass of planet
- r = radius of the planet

Drawing Electric Field Lines

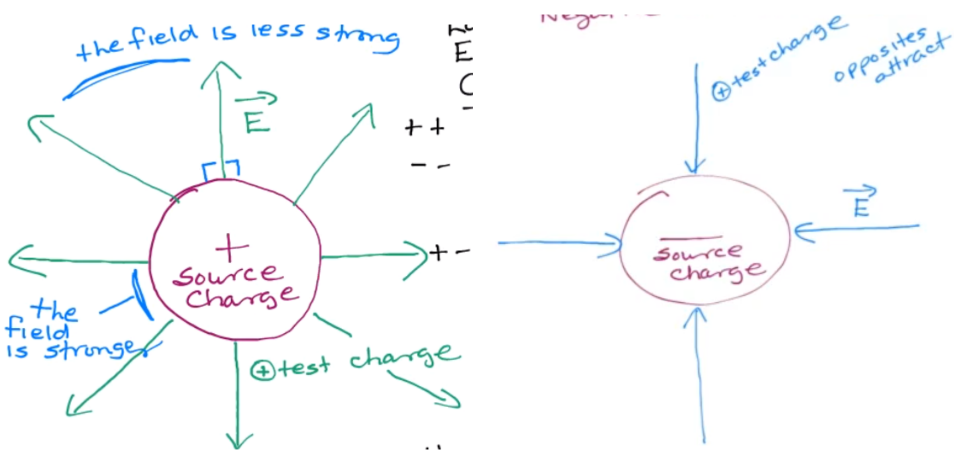


- Like charges repel, opposite charges attract
- The field is stronger the closer to the source charge it is
- We **always** use a small positive test charge to map/draw the electric field

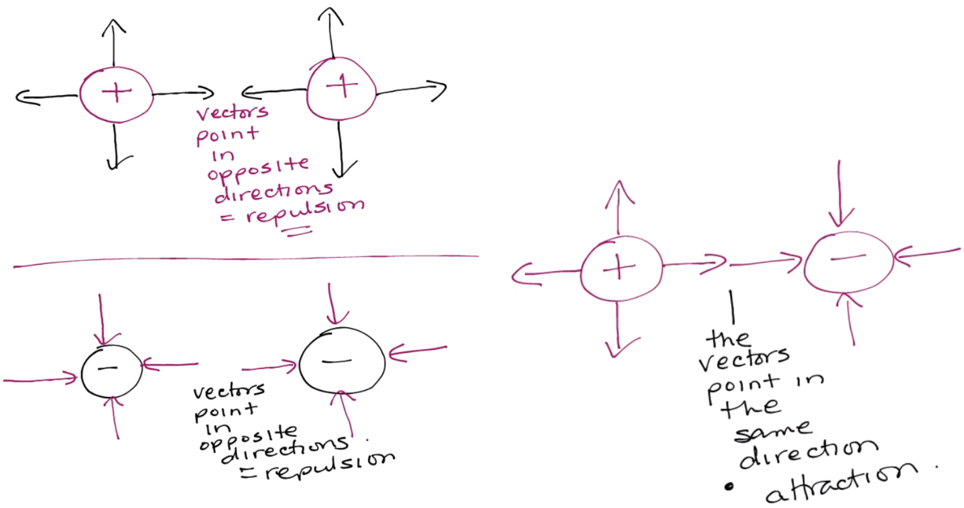
Rules

- The lines must originate on a positive charge and end on a negative charge (positive to negative)
- The electric field line must be perpendicular to the surface of the charge
- The number of lines drawn leaving a positive charge or approaching a negative charge is proportional to the magnitude of the charge
- No two field lines can cross each other

Electric Field Around A Positive v/s Negative Source Charge



Electric Field Interactions



Use this theory with a test particle to determine the direction of an electric field. NOT signs.

Particles

	charge	mass
Alpha particles	$+3.20 \times 10^{-19}$ C	6.65×10^{-27} kg
Electrons	-1.60×10^{-19} C	9.11×10^{-31} kg
Protons	$+1.60 \times 10^{-19}$ C	1.67×10^{-27} kg
Neutrons	0C	1.67×10^{-27} kg

Electric Field Strength

Electric Field Around A Producer (Source Charge)

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

$$\text{Units: } \frac{\mathsf{N}}{\mathsf{C}} \text{ or } \frac{\mathsf{V}}{\mathsf{m}}$$

- k = Coulomb's Constant ($8.99 \cdot 10^9$ N $\cdot$ m^2/C^2)
- q = Value of the source charge (C)
- r = Distance from the source charge (m)

Electric Field Experienced By A Charge

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

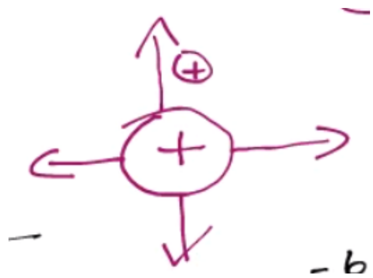
- $\vec{E}$ = Electric Field ($\frac{\mathsf{N}}{\mathsf{C}}$)
- $\vec{F}_e$ = Electrostatic Force (N)
- q = Test Charge (in a field question, its not source charge) (C)

Example

Calculate the electric field 2.00 cm from an alpha particle.

$$|\vec{E}| = \frac{(8.99 \cdot 10^9\,\mathsf{N \cdot m^2/C^2})(3.20 \cdot 10^{-19}\,\mathsf{C})}{(2.00 \cdot 10^{-2}\,\mathsf{m})^2}$$

$$|\vec{E}| = 7.19 \cdot 10^{-6}\,\frac{\mathsf{N}}{\mathsf{C}} \text{ radially outward}$$



Example II

Calculate the electric field strength at a point in space where a $3.24 \cdot 10^{-6}$ C charge experiences an electrostatic force of $5.29 \cdot 10^{-3}$ N.

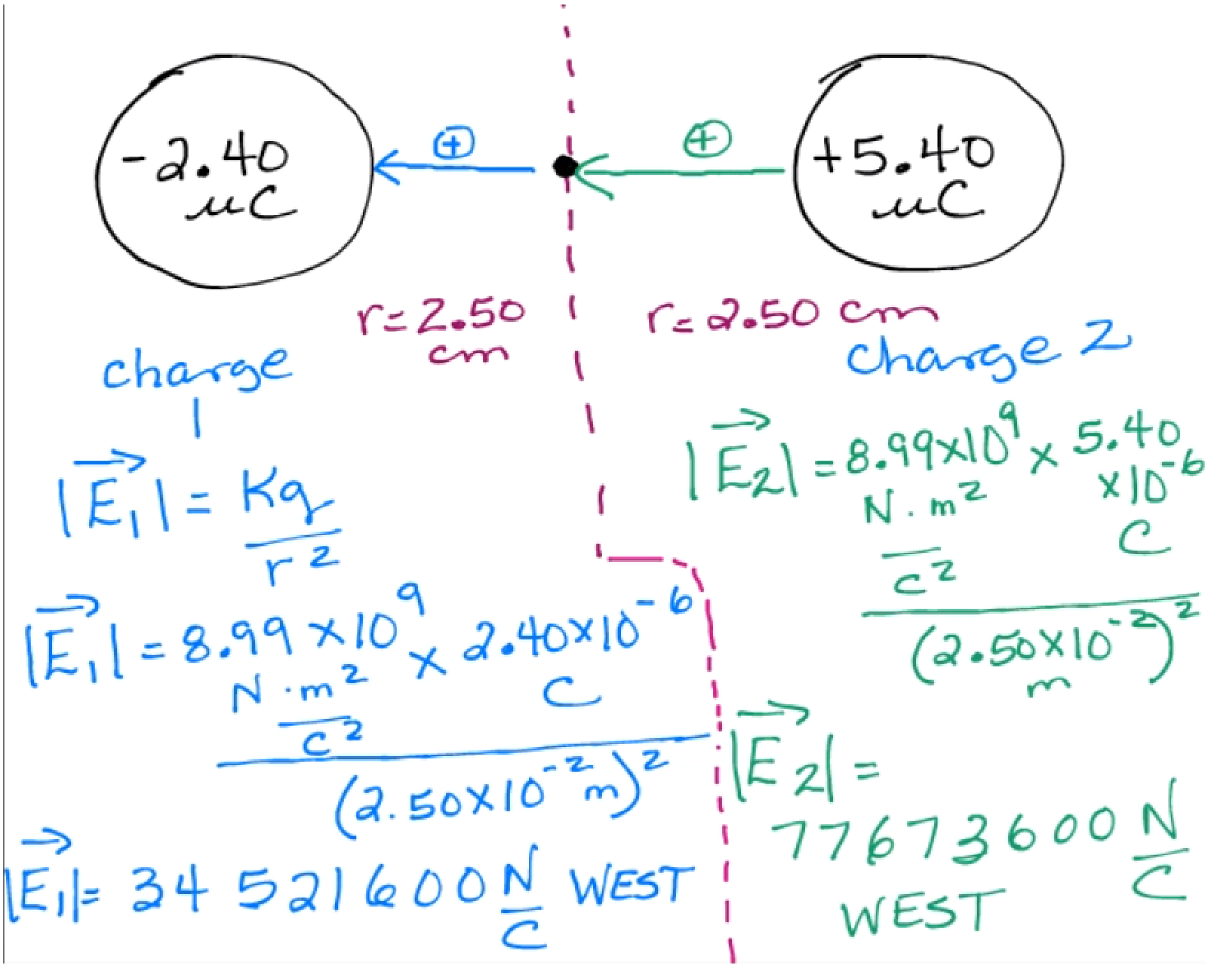
$$\vec{E} = \frac{\vec{F}_e}{q}$$

$$\vec{E} = \frac{5.29 \cdot 10^{-3}\,\mathsf{N}}{3.24 \cdot 10^{-6}\,\mathsf{C}}$$

$$\vec{E} = 1.63 \cdot 10^3\,\frac{\mathsf{N}}{\mathsf{C}}$$

Example III

Calculate the electric field midway between the two charges below if they are 5.00 cm apart.



$$|\vec{E}_{net}| = |\vec{E}_1| + |\vec{E}_2|$$

$$|\vec{E}_{net}| = 34\,521\,600\,\frac{\mathrm{N}}{\mathrm{C}},\text{ west} + 77\,673\,600\,\frac{\mathrm{N}}{\mathrm{C}},\text{ west}$$

$$|\vec{E}_{net}| = 1.12 \cdot 10^{8}\,\frac{\mathrm{N}}{\mathrm{C}},\text{ west}$$