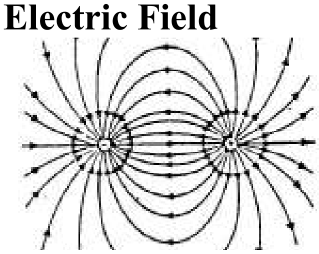
Electrostatics Basics

Charge
- Comes in + and –
- Like charges repel; unlike charges attract
- The proton has a charge of e
- The electron has a charge of -e
- e = 1.6×10^{-19} Coulombs
- The Coulomb is the SI unit of charge
- Charge is conserved
- Charge is quantized and only comes in increments of e

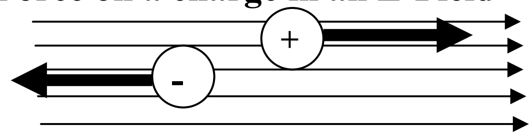
Net Charge
- An excess of either positive or negative charge
- Electrons either gained or lost (protons never transferred)
- An object can acquire a net charge in one of three ways
  - → **Charging by Friction**: two neutral objects are rubbed together, and electrons are rubbed off of one object and onto the other
  - → **Charging by Conduction**: a charged object touches a neutral object, usually a conductor
  - → **Charging by Induction**: a charged object is brought close to a neutral object, polarizing it, and the neutral object is grounded

Electric Field



- E-field lines start on + charges and end on – charges
- E-Field lines never cross
- The number of E-field lines is proportional to the amount of charge
- The density of the E-field lines represents the strength of the E-field
- The E-field points tangent to the E-field lines
- E-field has units: N/C

Force on a charge in an E-Field



- Electric field provides force to a charge
- $\vec{F} = q\vec{E}$
- Do NOT plug +/- of the charge into the equation. Use sign of charge to figure out direction only.
- + charges forced in the same direction as the E-field
- - charges forced in opposite direction as the E-Field

Problem: Electric Force from Field (1988)

Questions 17 -l8
An electron is accelerated from rest for a time of 10^{-9} second by a uniform electric field that exerts a force of 8.0 x 10^{-15} newton on the electron.

17. What is the magnitude of the electric field
(A) 8.0 x 10^{-24}N/C
(B) 9.1 x 10^{-22} N/C
(C) 8.0 x 10^{-6}N/C
(D) 2.0 x 10^{-5} N/C
(E) 5.0 x 10^{4} N/C

18. The speed of the electron after it has accelerated for the 10^{-9} second is most nearly

(A) 10^{1} m/s
(B) 10^{3} m/s
(C) 10^{5} m/s
(D) 10^{7} m/s
(E) 10^{9} m/s

Conductors

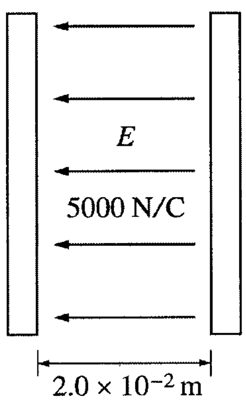
- Any net charge on a conductor distributes on the surface only.
- The electric field is ALWAYS zero inside a conductor.

Energy/Work

- Voltage provides energy to a charge
- $PE = q\Delta V$
- + charges "fall" from high voltage to low
- - charges "fall" from low voltage to high
- PE is converted to KE

Relation between E-field and Voltage

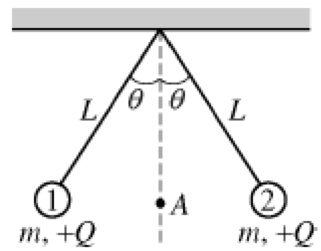
- $E = \frac{\Delta V}{d}$
- Only use for uniform E-field (parallel plates)



If an electron is released from rest midway between the plates, determine its speed just before striking one of the plates.

Force between two point charges (Coulomb's Law)

- $\vec{F} = k\frac{Q_1 Q_2}{r^2}$
- The constant $k = \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ \frac{Nm^2}{C^2}$
- Units: Newtons (N)
- Do NOT plug +/- of the charges into the equation. Use sign of charge to figure out direction only.
- The force on each charge is always equal and opposite (Newton's 3rd law)

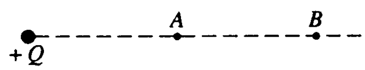


Find an expression for the force on particle 1 due to particle 2, and state its direction.

E-field of a point charge

- $\vec{E} = \frac{kQ}{r^2}$
- Units: N/C
- Stronger when closer to charge
- Points away from + charge, towards – charge
- Add multiple E-Fields like VECTORS
- Do NOT plug +/- of the charges into the equation. Use sign of charge to figure out direction only.

Problem: Electrical field calculation from point charges (1993)

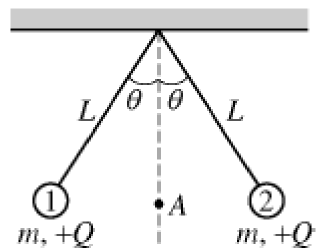


68. The diagram above shows an isolated, positive charge Q. Point B is twice as far away from Q as point A. The ratio of the electric field strength at point A to the electric field strength at point B is

(A) 8 to 1
(B) 4 to 1
(C) 2 to 1
(D) 1 to 1
(E) 1 to 2

Voltage of a point charge

- $V = \frac{kQ}{r}$
- Units: Volts (V) or J/C
- Stronger when closer to charge
- Add multiple voltages like a SCALARS
- ALWAYS ALWAYS ALWAYS plug +/- of the charges into the equation. Negative charges have negative voltages; positive charges have positive voltages.
- "Voltage", "electric potential", and "potential" are all the same thing.



Determine the electric potential at point A.