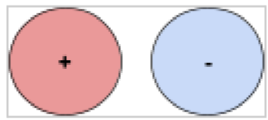
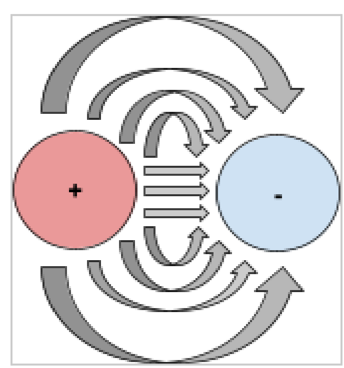
Lab: AP Review Sheets **AP Physics**
Chapter 5: Electric Forces and Fields by Patrick Seo

Electric Charge:

- Positive charge
    - Exhibited by protons (charge = +1.602e-19C)
    - Generates “flow of positive charges” - not actually moving
- Negative charge
    - Exhibited by electrons (charge = -1.602e-19C)
    - Generates “flow of negative charges” - actually does move



- Charging by…
    - Conduction
        - A charged conductor (metal) touches a neutral conductor
        - Free electrons pass from one object to another
    - Induction
        - A charged object is brought near a neutral conductor
    - Grounding
        - Connecting a conductor to the literal ground
        - (Earth has plenty electrons -> Readily accepts/gives up electrons
        - Allows for flow of charges in conductors
- Conservation of Charge: “Net amount of electric charge produced in any charge = 0”
- Polarization: When the centers shift slightly, in the presence of a charged object, resulting in a more positive charge on one side of the molecule than the other side
- Induction: The motion of negative charges on the sphere causing the positive charges to become uniformly distributed over the outside
- Different Types of Materials
    - Insulator: Electric charges DON’T move freely / Charged by contact and polarization
    - Conductor: Electric charges DO move freely / Charged by contact and induction
    - Semiconductor: Characterized by electric properties between conductors and insulators
    - Superconductor: Become perfect conductors AT/BELOW a certain temperature
- Relationship b/w Gravitational and Electric Forces:
    - Alike: Inversely proportional to square of distance b/w two charges
    - Different:
        - Gravitational: Always attractive
        - Electric: Attractive OR Repulsive (Creates electric fields)



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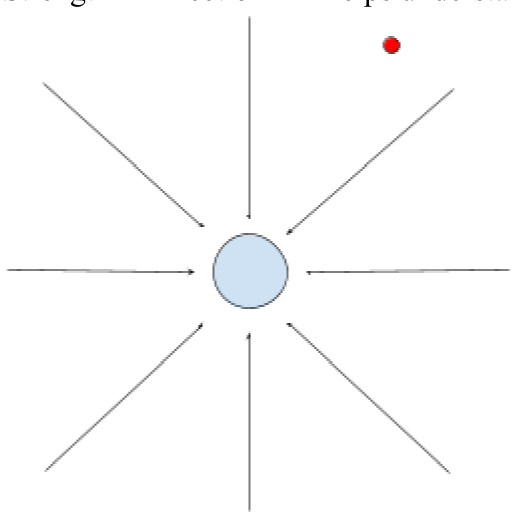
Coulomb's Law:
- $F = k * (q_1 * q_2) / r^2$
  - F = Force b/w charges
  - k = Coulob's constant = 9.00e9 $N \cdot m^2/C^2$ [can also be defined as $1/(4\pi\varepsilon_0)$]
  - q_1, q_2 = charges
  - r = distance b/w charges
- "The closer two charges are to each other, the stronger the force between them"
- Like charges: repel / Opposite charges: attract
- Resulting Force = (-): charges are attracted to each other
- Resulting Force = (+): charges are repelling each other
- Only applies to…
  - Non-moving charges => Electrostatic situations
  - Two charges (more than two charges requires the net force on any single charge to be equal to the net vector sum of the forces due to other charges

Electric Fields:
- Charges produce electrical disturbance in the region around it
- Electric fields represent the effect a charge has on the space around it, influencing other charges within the space
- Strength + Direction => Helps understanding of how forces act between charged objects



$$\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}}{q_o} = \frac{k\frac{q_1 q_o}{r^2}}{q_o} = k\frac{q_1}{r^2}$$

  - E = Electric Field
  - q = Charge
  - r = Distance from charge

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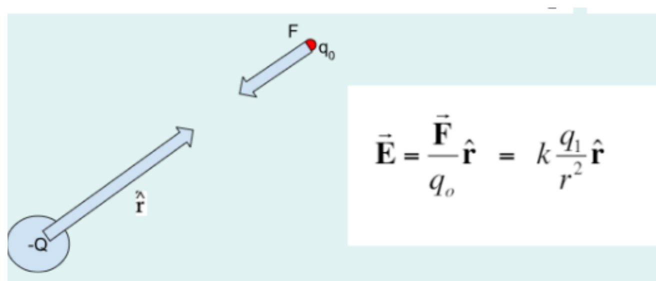
- Electric Field due to One Point Charge



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- Electric Field due to Two Or More Point Charges

$$\vec{\mathbf{E}}_{net} = \sum_i k\frac{q_i}{r_i^2}\hat{\mathbf{r}} = k\sum_i \frac{q_i}{r_i^2}\hat{\mathbf{r}}$$

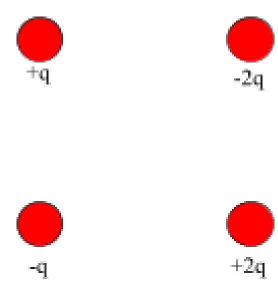
- Continuous Charge Distribution
    - E’ = ∫(k * dq / r^2)
    - λ = q / L → dq = λ * dL
    - σ = q / A → dq = σ * dA
    - ρ = q / V → dq = ρ * dV
- Determining Acceleration of a Charge in an Electric Field
    - E = F / q, F = qE, F_net = ma, a = (qE) / m
        - a = acceleration
        - m = mass of charge
        - q = charge
        - E = Electric Field Strength

FRQS:

1. (easy) What is the magnitude of a point charge whose E-field at a distance of 25 cm is 3.4 N/C?

2. (moderate) A dipole is set up with a charge magnitude of 2x10-7 C for each charge (one is positive and the other is negative.) The distance between the charges is 0.15 m. What are the magnitude and direction of the E-field at the midpoint of the dipole? (Assume the positive charge is on the left.) Also determine the force magnitude and direction for an electron at that position in the field.

3. (hard) Find the E-field (both magnitude and direction) at the center of the square charge distribution shown below. Note that the charges are NOT equal. Assume that the sides of the square have a length L.



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Answers:

1)

E= kq/r2

3.4 = (9x109)q/(0.25)2

q = 2.4x10-11C

2)

The E-field from both charges will point to the right, thus the overall E-field is to the right. The magnitude of the overall E-field is the addition of the two E-fields caused by the charges:

E = E+ + E- = kq/r2 + kq/r2 = kq(1/r2 + 1/r2)

E = (9x109)(2x10-7)(1/(0.15/2)2 + 1/(0.15/2)2)

E = 640000 N/C

The force on the electron is F=qE

F = (1.6x10-19)(640000) = 1x10-13N

3)

To solve this problem you need to superposition the E-fields of all four charges. The distance (r) to the center for any charge is the same (L/√2). Use the standard coordinate system to measure the angles below.

The lower left charge produces an E-field pointing at 225° with a magnitude of

E= kq/r2 = 2kq/L2

The upper left charge produces an E-field pointing at 315° with a magnitude of

E = kq/r2 = 2kq/L2

The lower right charge produces an E-field pointing at 135° with a magnitude of

E = k2q/r2 = 4kq/L2

The upper right charge produces an E-field pointing at 45° with a magnitude of

E= k2q/r2 = 4kq/L2

The x-components of this superposition cancel out. The y-components add together in the following manner:

E = [(2kq/L2)(sin 225) + (2kq/L2)(sin 315) + (4kq/L2)(sin 135) + (4kq/L2)(sin 45)]

E= (2√2)kq/L2 (in the +y direction)