Recitation 4.6 Review

1. Three point charges are arranged along the x axis. Charge \( q_1 = +3.00 \mu C \) is at the origin, and charge \( q_2 = (-5.00) \mu C \) is at \( x=0.20 \text{ m} \). Charge \( q_3 = (-8.00) \mu C \). Where is charge \( q_3 \) located if the net force on \( q_1 \) is 7.00N in the \((-x)\) direction?

\[-0.144 \text{ m}\]

2. A proton is placed in a uniform electric field of \( 2.75 \times 10^3 \text{ N/C} \). Calculate:
   a. The magnitude of the electric force felt by the proton.
   b. The proton’s acceleration
   c. The proton’s speed and position after 1.00 \( \mu \text{s} \) in the field, assuming it starts from rest.

[\text{a. } 4.41 \times 10^{-16} \text{ N}; \text{ b. } 2.63 \times 10^{11} \text{ m/s}^2; \text{ c. } 2.63 \times 10^5 \text{ m/s, 0.132 m}]}

3. A small particle has a charge of \( (-5.00) \mu C \) and a mass of \( 2.00 \times 10^{-4} \text{ kg} \). It moves from point A, where the electric potential is \( V_A = +200 \text{ V} \), to point B where the electric potential is \( V_B = +800 \text{ V} \). The electric force is the only force acting on the particle. The particle has a speed of 5.00 m/s at point A. What is its speed at point B?

\[ 7.42 \text{ m/s} \]

4. In the figure to the right, \( C_1 = 6.00 \mu F, C_2 = 3.00 \mu F, C_3 = 5.00 \mu F \). After the charges on the capacitors have reached their final values, the charge on \( C_3 \) is 40.00 \( \mu C \).
   a. What are the charges on capacitors \( C_1 \) and \( C_3 \)?
   b. What is the applied voltage \( V_{ab} \)?

[\text{a. } Q_1 = 80 \mu C, Q_3 = 120 \mu C; \text{ b. } 37.3 \text{ V}]}

5. In household wiring, 12 gauge copper wire (2.05 mm diameter) is often used. Find the resistance of a 24.0 m (78.7 ft) length of this wire.

[0.125\Omega]

6. Each resistor in the circuit represents a light bulb with a resistance of 4.5\Omega. The voltage source is 9.0V. Which bulb or bulbs glow the brightest?

\[ P_1 = 10.1 \text{ W} \]

Now bulb R4 is removed from the circuit. Does bulb 1 glow brighter or duller with R4 removed?

\[ P_1 = 8.0 \text{ W} \]

7. Two hikers are reading a compass under an overhead transmission line that is 5.50 m above the ground and carries a current of 800 A in a horizontal direction from north to south. Find the magnetic field at a point on the ground directly underneath the conductor. Considering that the magnitude of the earth’s field is on the order of \( 0.5 \times 10^{-4} \text{ T} \), is the current really a problem?

\[ B = 2.91 \times 10^{-7} \text{ T} \]
 Constants
\[ m_e = 9.109 \times 10^{-31} \text{ kg} \]
\[ m_p = 1.673 \times 10^{-27} \text{ kg} \]
\[ m_n = 1.675 \times 10^{-27} \text{ kg} \]
\[ k = 9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2} \]
\[ \varepsilon_0 = 8.854 \cdot 10^{-12} \frac{\text{C}^2}{\text{Nm}^2} \text{ or } \frac{\text{F}}{\text{m}} \]
\[ e = -1.6022 \cdot 10^{-19} \text{ C (electron charge)} \]
\[ eV = 1.6022 \cdot 10^{-19} \text{ J (electron volt)} \]

**Coulomb’s Law (electrostatic force)**
\[ F = \frac{k |q_1q_2|}{r^2} \]
\[ F = \frac{1}{4\pi \varepsilon_0} \frac{|q_1q_2|}{r^2} \]

**Electric Field – point charge**
\[ \vec{E} = \frac{\vec{F}}{q} = \frac{1}{4\pi \varepsilon_0} \frac{q}{r^2} \]

**Potential energy - point charges**
\[ U = \frac{1}{4\pi \varepsilon_0} \sum q_iq_j \frac{1}{r_{ij}} \]

**Potential**
\[ V = \frac{U}{q_0} \]

**Potential of a set of point charges**
\[ V = \frac{1}{4\pi \varepsilon_0} \sum q_i \frac{1}{r_i} \]

**Potential difference between two parallel plates**
\[ V_x - V_y = Ed \]

**Capacitance**
\[ C = \frac{Q}{V_{ab}} \]
\[ 1F = \frac{1C}{1V} \]

**Capacitance – parallel plates**
\[ C = \frac{\kappa \varepsilon_0 A}{d} \]

**Capacitance – energy storage**
\[ U = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} CV^2 = \frac{1}{2} \dot{Q} \dot{V} \]

**Capacitors in series**
\[ \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \]

**Capacitors in parallel**
\[ C_{eq} = C_1 + C_2 + C_3 + \cdots \]

**Resistors in series**
\[ R_{eq} = R_1 + R_2 + R_3 + \cdots \]

**Resistors in parallel**
\[ \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \]

**Current**
\[ I = \frac{dQ}{dt} \]
\[ 1A = \frac{1C}{1\text{sec}} \]

**Kirchhoff’s Rules**
\[ \sum V = 0 \text{ for a closed loop} \]
\[ \sum I = 0 \text{ for a junction} \]