1. (14 pts) Three point charges are placed along the x-axis: \( q_1 = 14.0 \, \text{nC} \) is at the origin, \( q_2 \) of unknown charge is at \( x = 2 \, \text{m} \), and \( q_3 = -17.0 \, \text{nC} \) is at \( x = 5 \, \text{m} \). What are the sign and magnitude of the unknown charge if the net electric field at \( x = 8 \, \text{m} \) has magnitude 12 N/C and is in the +x direction?

\[
E = \frac{q}{r^2}
\]

\[
E_{\text{total}} = q_1 \left( \frac{6}{(2)^2} \right) + q_2 \left( \frac{3}{8} \right) + q_3 \left( \frac{3}{5} \right) = 12 \, \text{N/C}
\]

- Use Force instead of \( E \).
- Wrong sign for \( q_2 \).
- No force on \( q_3 \).
- Wrong sign for \( q_2 \).
- Correct magnitude: \( q_2 = 0.8 \, \text{nC} \)

2. (14 pts) Two small spheres of mass \( m = 0.022 \, \text{kg} \) are hung by threads from a common point. When the spheres are given equal quantities of negative charge, each thread hangs at \( \theta = 35^\circ \) from the vertical, and the spheres are 0.8 m apart. What is the magnitude of q?

\[
\vec{F} = \vec{T} \cos \theta - mg = 0
\]

\[
T = \frac{mg}{\cos \theta}
\]

\[
T = 2.63 \, \text{N}
\]

\[
F = k \frac{q_1 q_2}{r^2}
\]

\[
q_2 = 1.08 \times 10^{-7} \, \text{C}
\]

\[
q_2 = 0.8 \, \text{nC}
\]

3. (14 pts) Two stationary point charges of +3.5nC and +2.1nC are separated by a distance of 0.5 m. An electron is released from rest at a point midway between the two charges and moves along the line connecting the two charges. What is the speed of the electron when it is 0.1 m from the +3.5nC charge? Hint: Acceleration is NOT constant.

\[
\frac{1}{2} m v^2 = \frac{-1}{4 \pi \varepsilon_0} \frac{q_1 q_e}{r} - \frac{1}{4 \pi \varepsilon_0} \frac{q_2 q_e}{r}
\]

\[
v = 7.52 \times 10^6 \, \text{m/s}
\]

4. (14 pts) A copper pipe 11.0 m long has an inside diameter of 6.0 cm and an outside diameter of 8.0 cm. What is the resistance of the pipe? \( \rho_{\text{copper}} = 1.72 \times 10^{-8} \, \Omega \cdot \text{m} \)

\[
R = \frac{\rho L}{A} = \frac{(1.72 \times 10^{-8} \, \Omega \cdot \text{m}) (11) \text{m}^2}{2.2 \times 10^{-2} \, \text{m}^2}
\]

\[
R = 8.6 \times 10^{-5} \, \Omega
\]
5. (14 pts) Determine the charge on capacitor $C_1$.

![Diagram of capacitors and voltages](image)

- (a) $Q_1 = C_1 V_1$
- (b) $Q_2 = C_2 V_2$
- (c) $V_1 = V_2 = \frac{16}{3} V$

6. (14 pts) A proton moving with a velocity of $4.4 \times 10^8 \text{ m/s}$ enters a region of a uniform magnetic field perpendicular to the x-axis. Upon entry into that region, the proton experiences an acceleration of $3.0 \times 10^{-5} \text{ m/s}^2$. Determine the magnitude and direction of the magnetic field.

- (a) $q = 1.602 \times 10^{-19} \text{ C}$
- (b) $m = 1.673 \times 10^{-27} \text{ kg}$

- (c) $F = m \cdot \vec{a}$
- (d) $F = m \cdot \frac{v^2}{R}$
- (e) $F = q \cdot B \cdot \vec{B}$

7. (14 pts) Determine $i_1$, $i_3$, and $V_1$ for this circuit.

![Circuit diagram with voltages and currents](image)

- (a) $i_1 = 1.677 \text{ A}$
- (b) $i_3 = 0.677 \text{ A}$
- (c) $V_1 = 10.8 \text{ V}$

Error in solution: should be $-k$.