Solutions to Midterm 1

Problem 1: A

Problem 2: B

Problem 3: A

Problem 4: A

Problem 5: C

Problem 6: A

Problem 7: \[ C = \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 \pi r^2}{d} \]

\[ C_0 = \frac{\varepsilon_0 \pi r_0^2}{d_0} \quad ; \quad r = 3r_0 \quad ; \quad d = 3d_0 \]

\[ C = \frac{\varepsilon_0 \pi r^2}{d} = \frac{\varepsilon_0 \pi (3r_0)^2}{3d_0} = 3 \frac{\varepsilon_0 \pi r_0^2}{d_0} = 3C_0 \]
PROBLEM 8:

\[ R = \frac{\rho L}{A} = \frac{\rho L}{\pi d^2/4} \]

\[ L_{\text{new}} = 3L \; ; \; \; d_{\text{new}} = 2d \]

\[ R_{\text{new}} = \frac{\rho L_{\text{new}}}{\pi (d_{\text{new}}/2)^2} = \frac{\rho \cdot 3L}{\pi (2d/2)^2} = \frac{3}{4} \frac{\rho L}{\pi (d/2)^2} = \frac{3}{4} R \]

PROBLEM 9:

For a pair of oppositely charged parallel metal plates \( V_{ab} = Ed \); \( F = 191E \)

(a) \( E = \frac{V_{ab}}{\Delta l} = \frac{360V}{45 \cdot 10^{-3} m} = 8000 \frac{V}{m} = 8000 \frac{N}{C} \)

(b) \( F = 191E = (2.40 \cdot 10^{-9} C) 8000 \frac{N}{C} = 1.92 \cdot 10^{-5} N \).
**Problem 10.**

The electric field of a negative charge is directed toward the charge.

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

The net field is the vector sum of the fields produced by each charge.

Point A is 0.100 m from \( q_2 \) and 0.150 m from \( q_1 \).

Point B is 0.100 m from \( q_1 \) and 0.350 m from \( q_2 \).

A charge in an electric field \( \vec{E} \) experiences a force \( \vec{F} = q \vec{E} \).
(a) The electric fields due to the charges at point \( A \) are shown in the figure:

\[
E_1 = K \frac{|q_1|}{r_{A1}^2} = \frac{8.99 \times 10^9 \text{ Nm}^2}{\text{C}^2} \frac{6.25 \times 10^{-9} \text{ C}}{(0.150 \text{ m})^2} = 2.50 \times 10^3 \frac{\text{ N}}{\text{ C}}
\]

\[
E_2 = K \frac{|q_2|}{r_{A2}^2} = \frac{8.99 \times 10^9 \text{ Nm}^2}{\text{C}^2} \frac{12.5 \times 10^{-9} \text{ C}}{(0.100 \text{ m})^2} = 1.124 \times 10^4 \frac{\text{ N}}{\text{ C}}
\]

Since the fields are in opposite directions we subtract their magnitudes to find the net field.

\[
E = E_2 - E_1 = 8.74 \times 10^3 \frac{\text{ N}}{\text{ C}} \text{ to the right}
\]
(b) The electric fields at point B are shown in the figure.

\[ E_1 = K \frac{q_1}{r_{B1}^2} = 8.99 \times 10^9 \ \text{N} m^2 \ \frac{C^2}{(0.100 \text{m})^2} \]
\[ = 5.619 \times 10^3 \ \text{N/C} \]

\[ E_2 = K \frac{q_2}{r_{B2}^1} = 8.99 \times 10^9 \ \text{N} m^2 \ \frac{C^2}{(0.350 \text{m})^2} \]
\[ = 9.17 \times 10^2 \ \text{N/C} \]

Since the fields are in the same direction, we add their magnitudes to find their net electric field.

\[ E = E_1 + E_2 = 6.54 \times 10^3 \ \text{N/C} \text{ to the right} \]

(c) At A, \( E = 8.74 \times 10^3 \ \text{N/C} \text{ to the right} \).

\[ F = qE = 1.60 \times 10^{-19} \ \text{C} \times 8.74 \times 10^3 \ \text{N/C} = 1.40 \times 10^{-15} \ \text{N to the right} \]