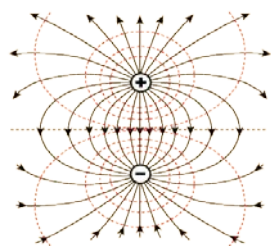


## Problem Set 2 – With Solutions

### Question 1 (1 point)

Draw the electric field lines and equipotential lines for an electric dipole.



### Question 2 (3 points)

A rod sits horizontally along the x-axis with a continuous uniform charge distribution such that the linear charge density  $\lambda$  is 0.025 C/m, with one end of the rod at the origin and the other end of the rod at  $x = 0.35\text{m}$ . Find the electric potential at the point on the x-axis where  $x = 0.45\text{ m}$  given that the potential an infinite distance from the rod is defined as being equal to zero.

$$V = \frac{kq}{r} \rightarrow \lambda = \frac{Q}{L} \rightarrow Q = \lambda L \rightarrow dq = \lambda dL \rightarrow V = \int \frac{k dq}{r} = \int \frac{k \lambda dL}{L} = k \lambda \int_{0.1}^{0.45} \frac{dL}{L} = k \lambda \ln(L)$$

$$V = (9 \times \frac{10^9 \text{ Nm}}{\text{C}^2}) (\frac{0.025 \text{ C}}{\text{m}}) (\ln(\frac{.45}{.1})) = 3.38 \times 10^8 \text{ V}$$

### Question 3 (3 points)

In a Millikan Oil-Drop type experiment, oil drops with an excess charge of two electrons are suspended between the two plates. If the mass of the oil drop is one million times the mass of the proton, and the plates are 2.5 cm apart, what is the voltage of the upper plate relative to that of the lower plate? Assume a uniform field between the two plates.

When a drop of oil is suspended using a force diagram you can find that  $F_g = F_e$ .

$$mg = Eq \rightarrow V = |E|d \rightarrow mg = \frac{qV}{d} \rightarrow$$

$$V = \frac{mgd}{q} = \frac{(1000000)(1.67 \times 10^{-27} \text{ kg}) (\frac{9.81 \text{ m}}{\text{s}^2}) (0.025 \text{ m})}{1.6 \times 10^{-19} \text{ C}} = 1.27 \text{ mV}$$

Question 4 (3 points)

Two parallel plate capacitors are labeled A and B. Capacitor A is filled with air and has an area of  $15 \times 10^{-3} \text{ m}^2$  and a separation between the plates of 1.3 mm. Capacitor B is filled with mylar and has an area of  $7.5 \times 10^{-3} \text{ m}^2$  and a separation between the plates of 0.2 mm. What is the total capacitance of A and B if they are combined in series? What is the total capacitance of A and B if they are combined in parallel? If they are combined in parallel and a voltage of 8.5 V is applied across them how much energy will they store?

$$C = \frac{k\epsilon_0 A}{d}$$

$$C_A = \frac{(1) \left( 8.85 \times \frac{10^{-12} \text{ C}^2}{\text{Nm}^2} \right) (15 \times 10^{-3} \text{ m}^2)}{1.3 \times 10^{-3} \text{ m}} = 0.102 \text{ nF}$$

$$C_B = \frac{(3.2) \left( 8.85 \times \frac{10^{-12} \text{ C}^2}{\text{Nm}^2} \right) (7.5 \times 10^{-3} \text{ m}^2)}{0.2 \times 10^{-3} \text{ m}} = 1.06 \text{ nF}$$

$$C_{\text{series}} = \left( \frac{1}{C_A} + \frac{1}{C_B} \right)^{-1} = \left( \frac{1}{1.06 \text{ nF}} + \frac{1}{0.102 \text{ nF}} \right)^{-1} = 0.093 \text{ nF}$$

$$C_{\text{parallel}} = C_A + C_B = 0.102 \text{ nF} + 1.06 \text{ nF} = 1.16 \text{ nF}$$

$$E = C_{\text{parallel}} V^2 = (1.16 \text{ nF})(8.5 \text{ V})^2 = 4.2 \times 10^{-8} \text{ J}$$