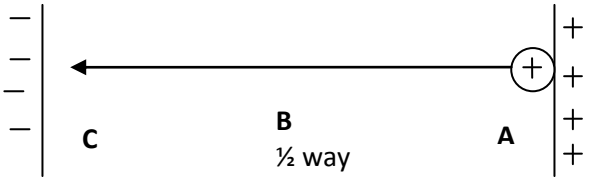
Millikan's Experiment – Mathematical Analysis

Looking at Potential Difference (ΔV)

(Look at $\mathcal{E} = \Delta V/\Delta d$ -- Constant field strength between parallel plates. This is a very handy way to find field strength, $\mathcal{E}$, since we can easily measure distance between 2 plates and the voltage applied.

The field strength ($\mathcal{E}$) between 2 parallel plates is called a 'gradient', which means it's a change in one value (ΔV) relative to a change in position (Δd). If $\mathcal{E}$ is constant between the plates, then mathematically as the charged particle moves across and lessens Δd, then the voltage , ΔV, must also lessen.



Assuming A and C are at the plates, A-C has the greatest potential difference (ΔV) and B-C has ½ the potential difference.

1. Calculate the electric field intensity between 2 parallel plates, 4.2 cm apart, which have a potential difference across them of 60.0 V. **[1.4 x 10^3 N/C]**

2. The potential difference between 2 points 8.0 mm apart in the field between 2 parallel plates is 24 V.
   a) What is the electric field intensity between the plates? **[3.0 x 10^3 N/C]**
   b) The plates themselves are 2.0 cm apart. What is the electric potential difference between them. **[60 V]**

3. When an 80.0 V battery is connected across a pair of parallel plates, the electric field intensity between the plates is 360 N/C.
   a) What is the distance of separation of the plates? **[0.222 m]**
   b) What force will be experienced by a charge of -4. 0 μC placed at the midpoint between the plates? **[1.44 x 10^{-3} N toward positive plate]**
   c) Calculate the force experienced by the charge in part (b) if it is located one quarter of the way from the positive plate. **[1.44 x 10^{-3} N toward positive plate]**

4. What electric potential difference must be applied across two parallel metal plates 8.0 cm apart so that the electric field intensity between them will be 3.2 x 10^2 N/C? **[26 V]**

5. The potential gradient between 2 parallel plates 2.0 cm apart is 2.0 x 10^3 V/m.
   a) What is the potential difference between the 2 plates? **[40 V]**
   b) What is the electric field intensity between the plates? **[2.0 x 10^3 N/C]**

Millikan's Math

An oil drop would be suspended in Millikan's apparatus when Fg [down] = Fe [up].

Fg [down] = Fe [up]

$mg = qt \cdot \varepsilon$

$$mg = qt \cdot \Delta V/\Delta d$$

So…to solve for the charge on a tiny oil droplet, Millikan used this final version of the formula:

$$qt = mg\Delta d/\Delta V$$

You try!

1. Two large horizontal parallel plates are separated by 2.00 cm. An oil drop, mass 4.02×10^{-15} kg, is held balanced between the plates when a potential difference of 820.0 V is applied across the plates, with the upper plate being positive.
   a) What is the charge on the drop?
   b) What is the number of electrons in excess or deficit?

2. A small latex sphere experiences an electric force of 3.6×10^{-14} N when suspended halfway between a pair of large metal plates, which are separated by 48.0 mm. There is just enough electric force to balance the force of gravity of the sphere.
   a) What is the mass on the sphere?
   b) What is the potential difference between the plates, given that the charge on the sphere is 4.8×10^{-19} C?