The Millikan Experiment

Used to determine the charge of a single electron.
Outline of apparatus
http://www.youtube.com/watch?v=XMfYHag7Liw&safe=active

More Detailed Explanation
http://www.youtube.com/watch?v=2HhaQtvICe8&safe=active

Note: Most explanations of the Millikan experiment involve the measurement of an oil drop with an excess of electrons, as your notebook does. The below video shows the experiment when there is a deficit of electrons (missing electrons), so now the bottom plate of the apparatus is now charged positively and the top is negative.
Example:
An oil drop with a mass of $2.55 \times 10^{-15}$ kg is balanced between two plates of a parallel capacitor. The upper plate is positive and the electric field strength between the plates is $E = 4.95 \times 10^4$ N/C. What is the charge on the drop, both in Coulombs and in elementary charges. Is it an excess or a deficit of electrons?

\[
\sum F = 0 = F_S + F_e
\]

\[
F_e = -F_S
\]

\[
= -mg
\]

\[
= -\left(2.55 \times 10^{-15} \text{ kg}\right) \left(-9.8 \text{ m/s}^2\right)
\]

\[
= 2.49 \times 10^{-14} \text{ N}
\]

\[
\therefore 2.5 \times 10^{-14} \text{ N}
\]
\[ E = \frac{F_0}{q} \]

\[ q = \frac{F_0}{E} \]

\[ = \frac{2.499 \times 10^{-14} N}{4.95 \times 10^4 \text{ N/K}} \]

\[ = 5.04848 \times 10^{-19} \text{ C} \]

or \[ -5.0 \times 10^{-19} \text{ C} \]
\[ q = 5.04848 \times 10^{-19} \text{ C} \]
\[ e^- = -1.602 \times 10^{-19} \text{ C} \]

Elemental charge:
\[ q = 1.602 \times 10^{-19} \text{ C} \]

Number of charges:
\[ N = \frac{q}{e^-} \]
\[ = \frac{5.04848 \times 10^{-19}}{-1.602 \times 10^{-19}} \]
\[ = -3 \text{ charges} \]

The drop has gained electrons.
Net Electric Fields
Electric Field lines for 2 or More Charges

• Suppose we have two +ve charges $Q_1$ and $Q_2$
• Each charge will create its own Electric Field
• Each field is a **vector** field
Example: A+ve point charge \( q_1 = +q \) produces a field \( E_1 = 2.0 \text{ N/C} \) at a colinear point "p". A -ve point charge \( q_2 = -q \) produces an electric field \( E_2 = 4.0 \text{ N/C} \) at the same point "p".
a) What is the magnitude and direction of the total electric field at "p"?

**Sol'n**

1. Start with a picture.
2. Since the question says "co-linear" and gives the electric field strength of each charge at the point "p" I can draw the charges in any order.
3. If I bring a small +ve test charge to point "p" I can determine what direction the electric field is pointed:
   1. Since like charges repel, \( E_1 \) repels the test charge or tends to move it away from \( q_1 \). ([R] in our drawing)
   2. Since opposite charges attract, \( E_2 \) attracts the test charge or tends to move it towards \( q_2 \) or also away from \( q_1 \). ([R] in our drawing)
4. [R] is generally considered a +ve direction so \( E_1 = +2.0 \text{ N/C} \) and \( E_2 = +4.0 \text{ N/C} \)
5. \( E_{\text{total}} = \sum E = E_1 + E_2 = +2.0 \text{ N/C} + (+4.0 \text{ N/C}) = +6.0 \text{ N/C} \)
6. More correctly I should give the field as \( E_{\text{total}} = 6.0 \text{ N/C} \) [toward -ve charge]
b) If a +5.0 C charge is placed at "p' what is the force acting on that charge?

(F and E are in the same direction)

\[ E = \frac{F_e}{q} \]
\[ F_e = E q \]
\[ = (6.2 \times 10^9) \times 5.0 \times 10^{-9} \]
\[ = 30 \text{N} \\text{[R]} \text{ toward } -\text{ve charge} \]
Study Pages 14-19
Complete questions
1-4 page 20
4 page 26
7-10 page 29
and page 34
Read pages 15 - 29

Complete questions 1-10 on pages 33-34

Complete questions 1- 4 on page 20