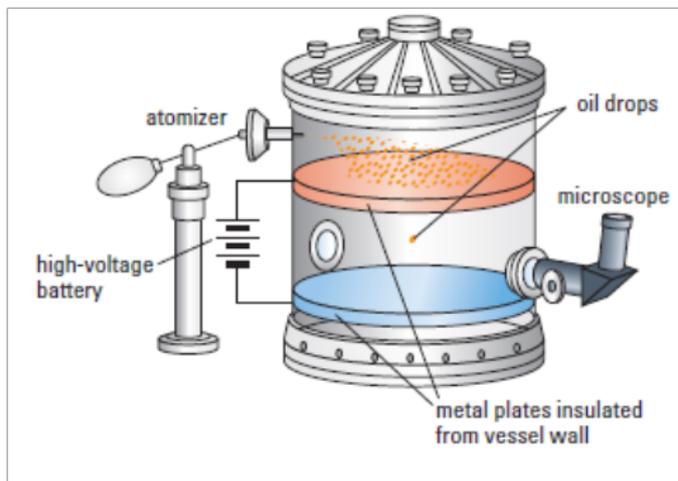# L17 – Millikan's Oil-Drop Experiment

Purpose: Explain Millikan's oil-drop experiment and its significance relative to charge quantization.

Key Result:
Charge is Quantized, e = 1.60 x 10^{-19} C
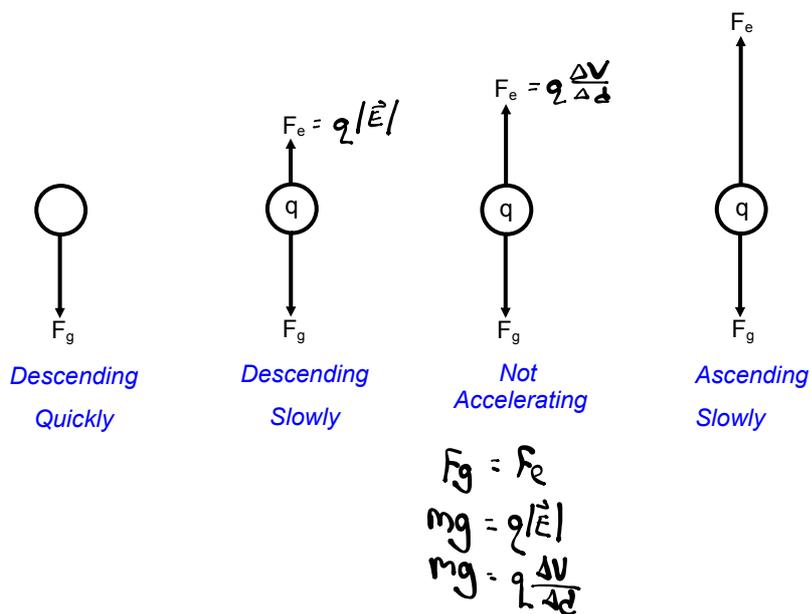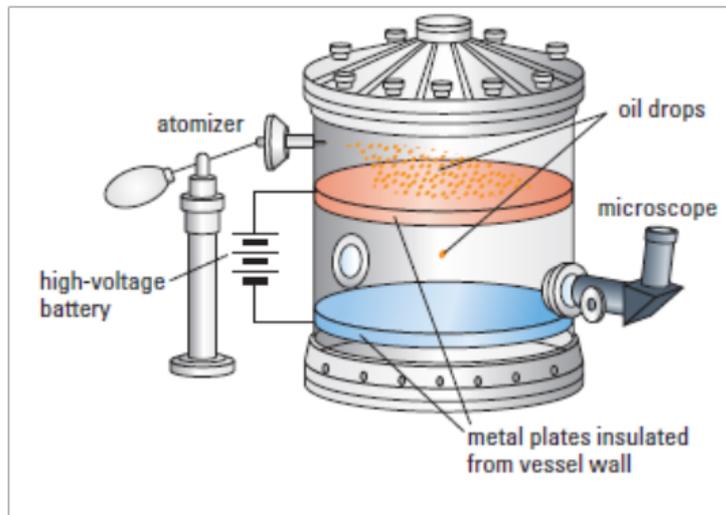

Indoor Skydiving Analogy regarding Unbalanced Forces

Descending

F_f

F_g

Not Accelerating

F_f

F_g

Millikan's Oil-Drop Experiment

$F_e = q|\vec{E}|$

$F_e = q\frac{\Delta V}{\Delta d}$

F_e

F_g F_g F_g F_g

Descending   *Descending*   *Not*   *Ascending*

Quickly   *Slowly*   *Accelerating*   *Slowly*

$$F_g = F_e$$
$$mg = q|\vec{E}|$$
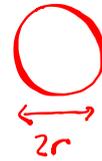$$mg = q\frac{\Delta V}{\Delta d}$$

𝕸illikan – 𝖂ith the 𝕸aths

$$v = \frac{4}{3}\pi r^3$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$

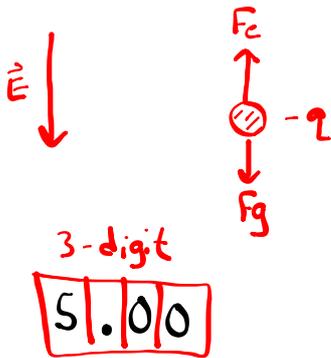$$\vec{g} = \frac{\vec{F}_g}{m}$$

$$\vec{F}_e = q\vec{E}$$

$$\vec{F}_g = m\vec{g}$$

Where $\left|E\right| = \frac{\Delta V}{\Delta d}$

Where $\rho = \frac{m}{v}$

Density $= \frac{Mass}{Volume}$

$\rho = \frac{m}{v}$

Q1: An oil droplet of mass 8.2 x 10⁻¹⁵ kg is suspended in an electric field of 1.0 x 10⁵ N/C down. How many electrons has the oil drop gained or lost?

$\vec{E} \downarrow$

$F_e \uparrow$

$\ominus -q$

$F_g \downarrow$

3-digit

| 5 | . | 0 | 0 |

$F_e = F_g$

$q|\vec{E}| = mg$

$q(1.0 \times 10^5) = (8.2 \times 10^{-15})(9.81)$

$|q| = 8.0442 \times 10^{-19} C$

$|e = 1.60 \times 10^{-19} C$

$q = -5.027625 e$

$q = -5e$ Gained 5 electrons

Q2: A tiny plastic sphere of mass 8.2 x 10⁻¹⁵ kg is placed in an electric field of 1.0 x 10⁵ N/C [down] within a vacuum chamber. The sphere has 10 excess electrons. Determine whether the sphere will accelerate, and if so, in which direction.

$F_e \uparrow$

$\ominus -Q$

$\vec{E} \downarrow$

$F_g \downarrow$
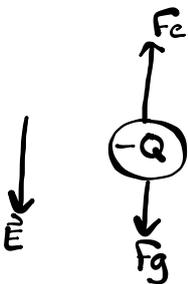
$F_g = mg$
$= (8.2 \times 10^{-15})(9.81)$
$= 8.0442 \times 10^{-14} N$

$F_e = q|\vec{E}|$
$= (10 \times 1.60 \times 10^{-19})(1.0 \times 10^5)$
$= 1.60 \times 10^{-13} N$

Yes. Will accelerate upward.

Q3: During a Millikan oil – drop experiment, a student records the weights of five different oil drops. The student also records the electric field intensity necessary to hold each drop stationary between the two horizontal, parallel plates. Use a graph to calculate the elementary charge.
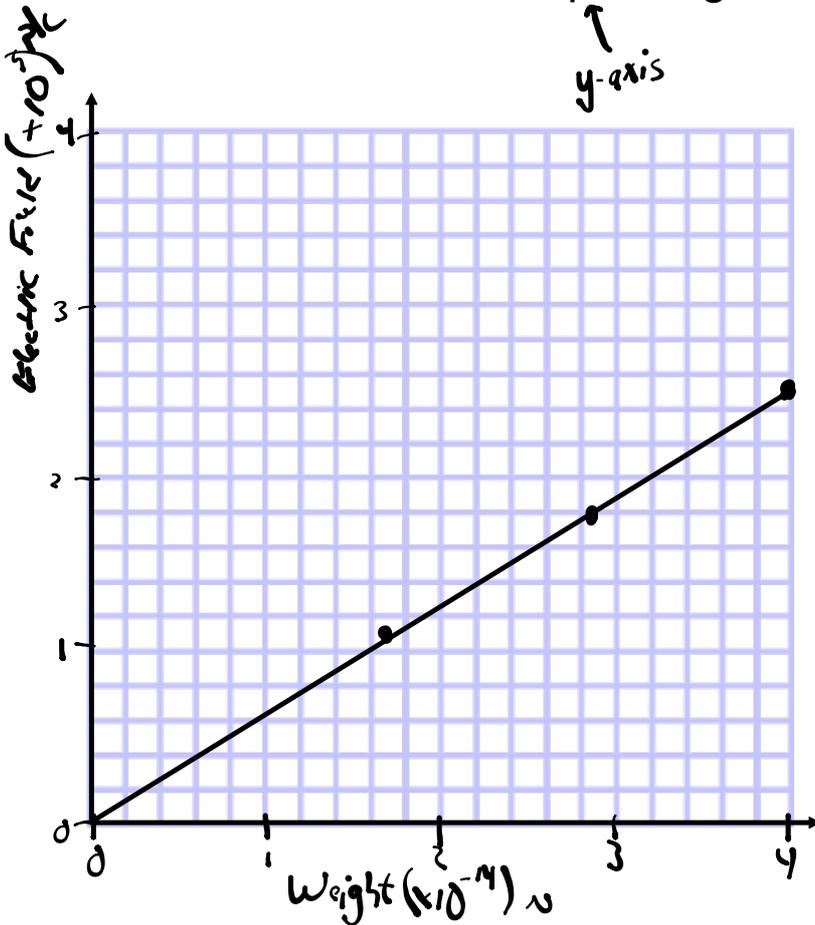
Weight ($\times 10^{-14}$ N)	Electric Field ($\times 10^5$ N/C)
1.7	1.1
5.6	3.5
6.1	3.8
2.9	1.8
4.0	2.5

Which variable **depends** on the other?

$\underline{\acute{E}-Field}$ **depends on** $\underline{Weight}$.
Dependent (y-axis)   Independent (x-axis)

— x-axis

$$\vec{F}_e = \vec{F}_g$$

$$q\vec{E} = m\vec{g}$$

↑
y-axis

$F_e = F_g$

$q|\vec{E}| = F_g$

$|\vec{E}| = \frac{1}{q}(F_g) + 0$

$y = m(x) + b$

$Slope = \frac{1}{q}$

$\frac{2.5 \times 10^5}{4.0 \times 10^{-14}} = \frac{1}{q}$

$6.25 \times 10^{18} = \frac{1}{q}$

$\boxed{q = 1.60 \times 10^{-19} C}$

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