Objective

- Milikan's **oil drop** experiment is used to verify the **quantization of charge.**
- Charge is *quantized*.
- The smallest possible unit of *charge* existing in nature is $1.6 \times 10^{-19} C$.

Working

- The **motion** of the *oil drop* is observed in absence of *electric field*
- The **motion** is observed after the application of **electric field** when the drop gains *terminal velocity.*

Construction

- A **double walled** chamber is taken.
- There are three windows w_1, w_2 and w_3 .
- **Light** is passed through w_1 .
- **Light** is passed for visibility.
- **X-Rays** are passed through w_2 .
- **X-Rays** are passed for ionization of *oil drop* .
- **A travelling microscope** is present in w_3 .
- **Travelling microscope** is used to observer the motion of *oil drop.*
- **Cold Water** is circulated through the **double walled** chamber.
- **Ionization** of oil drop produces heat.
- **Cold Water** maintains steady temperature.
- Two **circular** discs are fitted.
- *Positive* **Potential** is applied at the upper plate.
- **Negative** *Potential* is applied at the lower plate.
- **Atomiser** pushes clock oil to the plates.
- Upper plate has **hole** at the center.

Motion without $\vec{E}$

- The **drop** is considered as **sphere** .
- radius of the drop = r
- density of oil = ρ
- density of medium = σ
- coefficient of velocity = η
- The drop **moves** downward due to it's **weight** W .
- Viscous Force = F_{v_1}
- Upthrust = U
- Volume = V
- Terminal velocity = v_1

$$
\begin{aligned}
W &= F_{v1} + U \\
W - U &= F_{v_1} \\
mg - V\sigma g &= 6\pi\eta r v_1 \\
\rho V g - V\sigma g &= 6\pi\eta r v_1 \\
V g(\rho - \sigma) &= 6\pi\eta r v_1 \\
\frac{4}{3} r^3 g(\rho - \sigma) &= 6\eta r v_1 \\
r &= \sqrt{\frac{18\eta v_1}{4g(\rho - \sigma)}} \\
r &= \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}
\end{aligned}
$$

- The expression for **radius** of the drop is **expressed** as:

$$
r = \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}
$$

Motion with $\vec{E}$

- The **application** of **electric field** adds an extra **force** .

- The **force** is **electric force**

$$\begin{aligned} F &= qE \\ W &= U + F + F_{v_2} \\ W - U &= F + F_{v_2} \\ F_{v_1} - F_{v_2} &= F \\ qE &= 6\pi\eta r v_1 - 6\pi\eta r v_2 \\ qE &= 6\pi\eta(v_1 - v_2) \times r \end{aligned}$$

- The magnitude of **charge** if **drop** comes down is expressed as:

$$q = \frac{6\pi\eta(v_1 - v_2)}{E} \times \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}$$

- The magnitude of **charge** is **drop** goes up if **electric** field is high.

$$W + F = U + F_{v_2}$$

$$q = \frac{6\pi\eta(v_1 + v_2)}{E} \times \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}$$