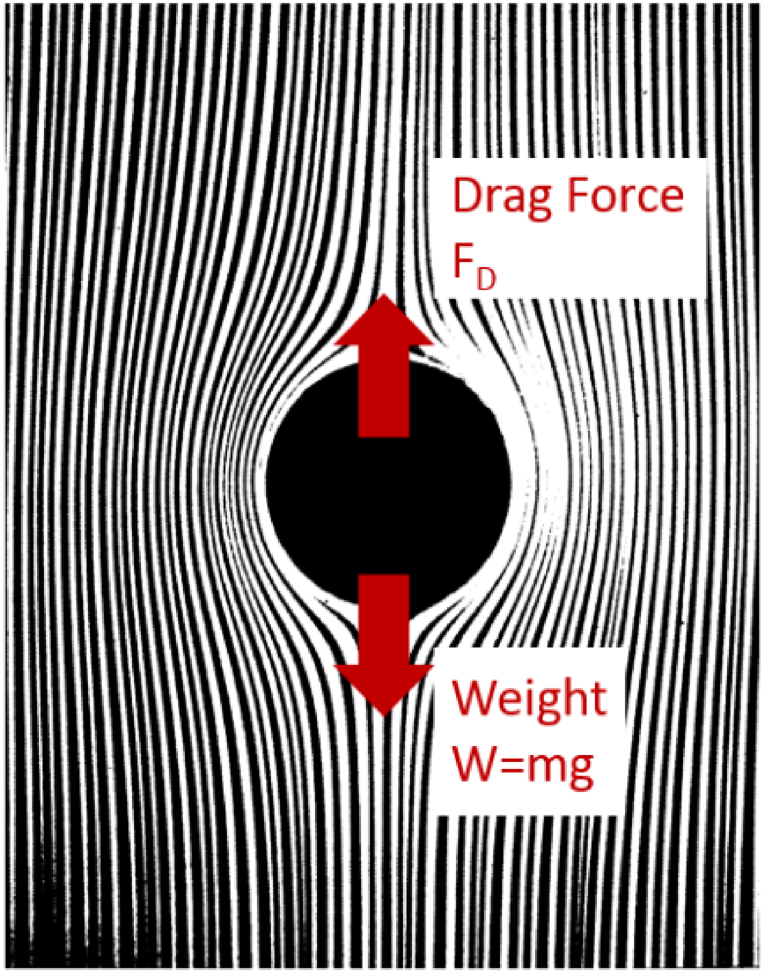
Example: Dimensional Consistency

- In Lab 1, the viscosity of engine oil is calculated by measuring the terminal velocity (V) of small spheres falling under the action of gravity (g).
- For very slow laminar flow ("Stokes Flow"):

$$\mu = \frac{D^2 g\,(\rho_{sphere} - \rho_{oil})}{18\,V}$$

Confirm the dimensional consistency of the Stokes equation.

- FINDING ERRORS
- DIMENSIONAL ANALYSIS (CHAPTER 5)



Streamlines for Laminar Flow Over a Sphere

$$\boxed{\mu = \frac{D^2 g(\rho_{SPHERE} - \rho_{OIL})}{18V}}$$

TABLE 1.2

$$\mu = \left\{\frac{M}{LT}\right\}$$

$$\tau = \mu \frac{du}{dy} \qquad \mu = \frac{\tau}{du/dy} \qquad \mu = \frac{\left\{\frac{F}{L^2}\right\}}{\left\{\frac{\cancel{L}}{T\cancel{L}}\right\}} = \left\{\frac{FT}{L^2}\right\}$$

$$F = ma \qquad \{F\} = \left\{M\frac{L}{T^2}\right\}$$

$$\mu = \left\{\frac{M\cancel{L}}{T\cancel{2}}\right\}\left\{\frac{\cancel{T}}{L^{\cancel{2}}}\right\} = \left\{\frac{M}{LT}\right\} \checkmark$$

TABLE 1.2

$$\boxed{\mu = \frac{D^2 g(\rho_{SPHERE} - \rho_{OIL})}{18V}}$$

$$\left\{\frac{M}{TL}\right\} = \frac{\{\cancel{L^2}\}\left\{\frac{\cancel{L}}{T\cancel{^2}}\right\}\left\{\frac{M}{\cancel{L^3}}\right\}}{\left\{\frac{L}{\cancel{T}}\right\}} = \left\{\frac{M}{TL}\right\} \quad \therefore \text{ CONSISTENT}$$