Lab 2a

Terminal velocity and drag forces

Today's lab

Our goal for the two-week sequence:

1. Demonstrate which drag force law $\boldsymbol{F}_{\text{drag}}(\boldsymbol{v})$ applies to small objects moving slowly in a fluid.
2. Figure out whether the objects we use in this lab qualify as "small" and "slow".

Ideally we would do this by pulling objects with a known $\boldsymbol{v}$ while measuring $\boldsymbol{F}_{\text{drag}}$. For technical reasons, we will instead apply a known $\boldsymbol{F}_{\text{applied}}$ (using gravity) and measure the terminal velocity $\boldsymbol{v}_{\text{term}}$.

Drag forces expressions

Viscous or Stokes drag:

$$\vec{F}_{Stokes} = -(6\pi\mu R V)\hat{v} \quad ?!$$

Aerodynamic drag:

$$\vec{F}_{aero} = -\left(\frac{1}{2}\rho C_d V^2\right)\hat{v} \quad ?!$$

μ = viscosity

R = radius

V = velocity

$-\hat{v}$: in the direction opposite velocity

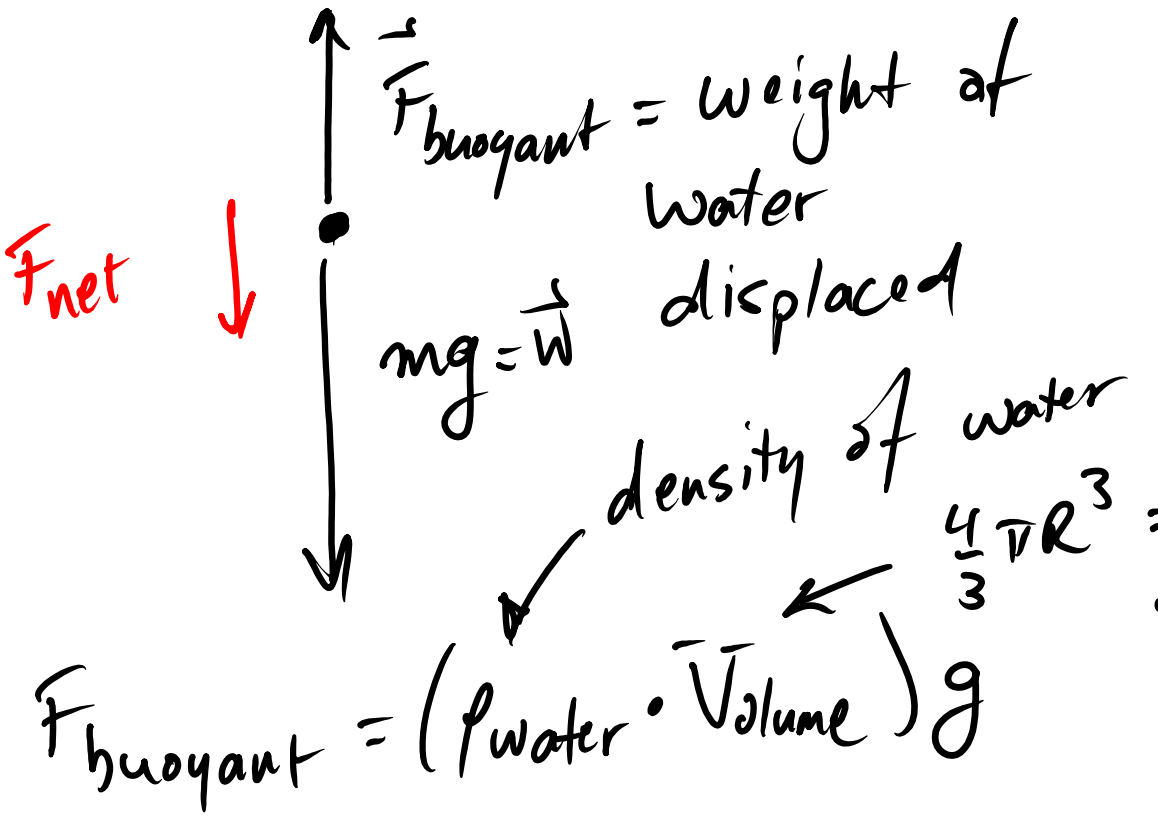
ρ : density of water

C_d : drag coefficient

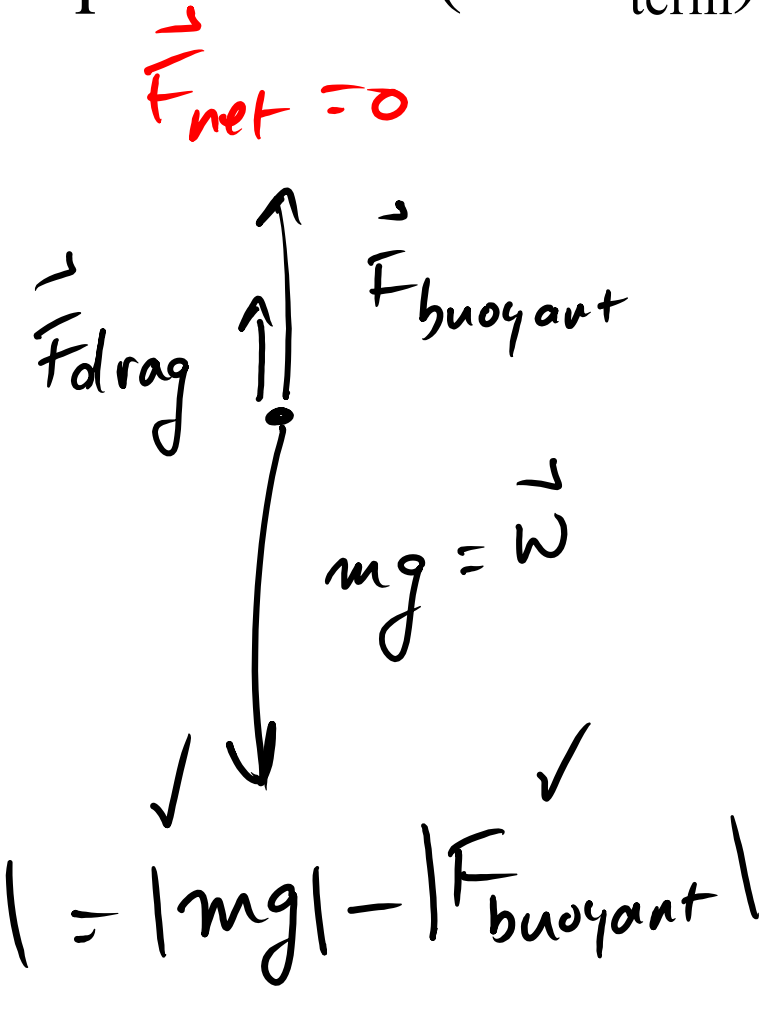
sphere $0.4 < C_d < 1$

Free body diagram

Initially ($v = 0$)



At dynamic equilibrium ($v = v_{term}$)



Today's lab

Our modest goal for today:

1. Record a bead falling in water.
2. Show that the bead has reached terminal velocity.
3. Measure the bead's terminal velocity.
4. Repeat terminal velocity measurement with 5 more beads (all the same size as the first bead).
5. Combine all 6 measurements into one number (plus error):

$$v_t \pm 2\Delta v_t$$