Viscous Drag

Relevant formula

1. $W = mg$, $weight\ = mass \times gravity$
2. $\rho = \frac{m}{V}$, $density\ = \frac{mass}{volume}$
3. $F = 6\pi\eta rv$, $drag\,force\ = 6 \times \pi \times density\,of\,fluid \times radius \times velocity$

Conditions of Stokes' formula

1. Small radius
2. Small velocity
3. Spherical ball
4. Laminar flow

Note

Viscosity changes with temperature. The higher the temperature the less viscous. The lower the temperature the higher the viscosity.

The weight of fluid displaced by an object is the amount of upthrust it faces. So

$$upthrust\ = V\rho g,\ volume\,of\,object \times density\,of\,fluid \times gravity$$

Derivation of big viscosity formula

We start with Stokes' law:

$$F = 6\pi\eta rv$$

If we draw the free body diagram then upthrust, U, is upwards. Weight, W, is downwards. Viscous drag, F, is in the opposite direction of motion. Let's say the ball is traveling downwards so viscous drag is upwards. So we have

$U + F = W$. Upthrust is same as weight of fluid displaced so, if ρ_1 is the density of the ball and ρ_2 is the density of the fluid, we have:

$$U = mass\, of\, fluid\, displaced \times g$$

$$= V\rho_2 g$$

$$W = mass\, of\, object \times g$$

$$= V\rho_1 g$$

Subbing these into $U + F = W$ we get:

$$V\rho_2 g + 6\pi\eta r v = V\rho_1 g$$

$$6\pi\eta r v = Vg(\rho_1 - \rho_2)$$

$$\eta = \frac{Vg(\rho_1 - \rho_2)}{6\pi r v}$$