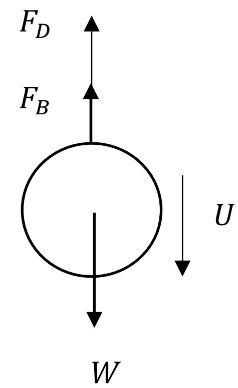
ME 55600/I0200
Homework #6: Solution

Using force balance:



$$F_D + F_B = W$$

$$6\pi\mu U R + \rho_{air} g \frac{4}{3}\pi R^3 = \rho_p g \frac{4}{3}\pi R^3$$

Solving for U:

$$U = \frac{2}{9\mu} g R^2 \rho_p \left(1 - \frac{\rho_{air}}{\rho_p}\right)$$

Since. $\frac{\rho_{air}}{\rho_p} \ll 1$ then $U = \frac{2}{9\mu} g R^2 \rho_p \sim \frac{\rho_p}{\mu} R^2 \; [m/s]$ Here $\frac{2g}{9} \sim O(1)$

Let $\rho_p \sim 10^3 \; kg/m^3$, $\mu \sim 10^{-5} \; kg/m - s$

For $R = 10^{-4} \; m$ $\quad U = \frac{10^3}{10^{-5}} (10^{-4})^2 \sim 1 \, m/s$ $\quad Re = \frac{UR}{\nu} \sim 10 \gg 1.$ (not valid);
$(\nu_{air} \sim 10^{-5} \; m^2/s)$

For $R = 10^{-5} \; m$ $\quad U = 0.01 \, m/s$ $\quad Re \sim 0.01$

A particle falling form 1 km, $\quad t = \frac{10^3}{0.01} = 10^5 s$ or 28 hrs.

A particle falling from 10 km, $\quad t \sim 12$ days.