

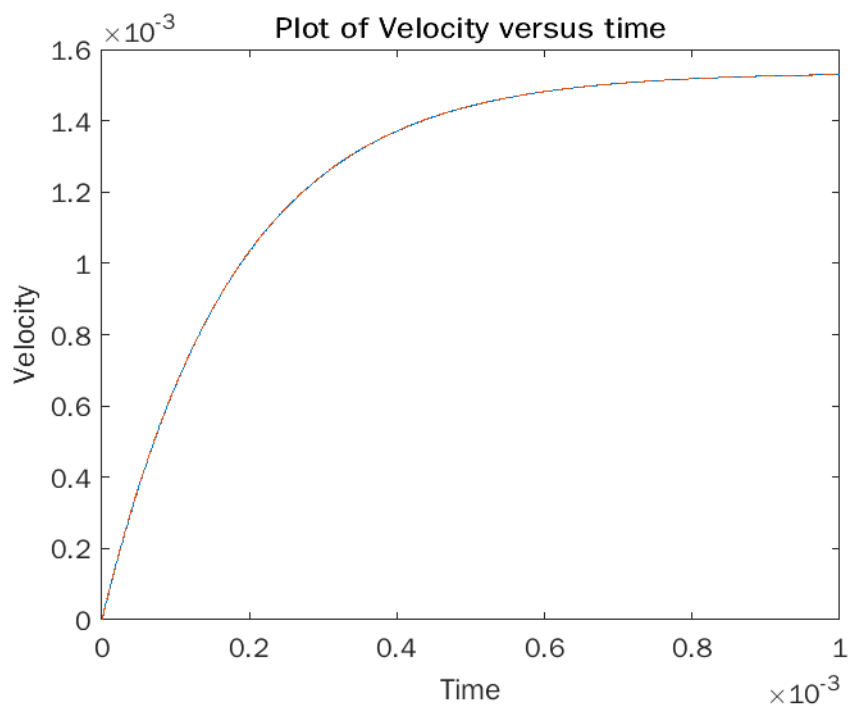
# BD Simulation Assignment 1

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## Analytical Expression Derivation

$$\begin{aligned}
 m \frac{du}{dt} &= mg - \rho_s V g - 6\pi n R u \\
 \Rightarrow \frac{du}{dt} &= g - \frac{\rho_s V g}{m} - \frac{6\pi n R u}{m} \\
 &= g - \frac{\rho_s \times \frac{4}{3} \pi R^3 g}{\rho_s \times \frac{4}{3} \pi R^3} - \frac{6\pi n R u}{\rho_s \times \frac{4}{3} \pi R^3} \\
 \frac{du}{dt} &= g - \frac{\rho_s g}{\rho_s} - \frac{9n R u}{2\rho_s R^2} \\
 \Rightarrow \int_0^u \frac{du}{g - \frac{\rho_s g}{\rho_s} - \frac{9n R u}{2\rho_s R^2}} &= \int_0^t dt \\
 \Rightarrow \frac{1}{-\frac{9n R}{2\rho_s R^2}} \ln \left( \frac{g - \frac{\rho_s g}{\rho_s} - \frac{9n R u}{2\rho_s R^2}}{g - \frac{\rho_s g}{\rho_s}} \right) &= t \\
 \Rightarrow 1 - \frac{\frac{9n R u}{2\rho_s R^2}}{g - \frac{\rho_s g}{\rho_s}} &= e^{-\frac{9n R t}{2\rho_s R^2}} \\
 \frac{2\rho_s R^2 (\rho_s - \rho_l) g}{9n R} (1 - e^{-\frac{9n R t}{2\rho_s R^2}}) & \\
 \boxed{u = \frac{2R^2 g (\rho_s - \rho_l)}{9n} (1 - e^{-\frac{9n t}{2\rho_s R^2}})} & \quad \text{Ans}
 \end{aligned}$$

Analytically Calculated Velocity and Numerically Calculated Velocity.



As we see there is very little difference in numerical and analytical calculations this means we can use numerical methods to calculate simple expressions with great precision