

FY8201 / TFY8 Nanoparticle and polymer physics I

EXERCISE 8

A bead with radius R and mass density ρ_s is placed in a Newtonian fluid with mass density ρ_0 and viscosity η . The bead is excited with time dependent displacements

$$x(t) = x_0 \sin(\omega t),$$

where $x(t)$ is the x -coordinate of the bead and ω is the angular frequency of the displacement. Let $F^{(m)}$ be the force of inertia and $F^{(h)}$ the hydrodynamic friction force on the bead.

A) Determine the ratio $\frac{|F^{(m)}|}{|F^{(h)}|}$ as function of ω and the bead radius R .

B) In dynamic studies of polymeres in solution it is common to assume $|F^{(m)}| \ll |F^{(h)}|$. Make a plot showing for which values of ω and R this assumption is valid when $\rho_s = 2.00 \text{ g/cm}^3$, $\rho_0 = 1.00 \text{ g/cm}^3$, and $\eta = 0.0010 \text{ Ns/m}^2$. (Plot the graph on log-log-scale.)

C) Assume that $x_0 = 1.00 \text{ }\mu\text{m}$. What are the Reynold numbers for the values of R and ω which you used in the calculation of $\frac{|F^{(m)}|}{|F^{(h)}|}$? Give the answer by e.g. indicating in the plot above where $Re = 0.1$ (the limit for laminar flow).