SIF40AH/DIF4997

Nano-particle and polymer physics I

EXERCISE 8

A bead with radius R and mass density ρs 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 $F^{(\mathrm{m})}$ be the force of inertia and $F^{(\mathrm{h})}$ the hydrodynamic friction force on the bead.

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

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

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