The viscosity is \( \eta \)
\[
\eta := 10^{-5} \frac{\text{kg}}{\text{cm} \cdot \text{s}}
\]

For a microscopic object moving through a viscous medium, the force required to move the object will be proportional to the length of the object, the viscosity, the speed and a factor relating to the shape: looks like a frictional force?

\[
\eta = 1 \times 10^{-3} \frac{\text{kg}}{\text{m} \cdot \text{s}}
\]

Translational drag on a sphere, holds for low Reynold's number

the drag coefficient \( f \) is:

\[
f_{\text{sphere}} := 6 \cdot \pi \cdot \eta \cdot a
\]

The force on this sphere is given by:

\[
F_{\text{sphere}} := f_{\text{sphere}} \cdot \nu
\]

\[
F_{\text{sphere}} = 3.77 \times 10^{-13} \text{ N}
\]

The Reynold's number is the ratio of intertial forces to viscous forces

\[
R_{\text{reynolds}} := \frac{\rho \cdot a \cdot \nu}{\eta}
\]

\[
R_{\text{reynolds}} = 2 \times 10^{-5}
\]

we are in the low Reynolds # range

For your reference, drag coefficients from Howard Berg's book for drag on objects of other shapes

translational drag of a disk:

where \( a \) is the radius of the disk

disk moving at random

\[
f_{\text{disk rand}} := 12 \cdot \eta \cdot a
\]

\[
f_{\text{disk rand}} = 1.2 \times 10^{-8} \frac{\text{kg}}{\text{s}}
\]

disk moving edge on

\[
f_{\text{disk edgeon}} := \frac{32}{3} \cdot \eta \cdot a
\]

\[
f_{\text{disk edgeon}} = 1.067 \times 10^{-8} \frac{\text{kg}}{\text{s}}
\]

disk moving face on

\[
f_{\text{disk faceon}} := 16 \cdot \eta \cdot a
\]

\[
f_{\text{disk faceon}} = 1.6 \times 10^{-8} \frac{\text{kg}}{\text{s}}
\]
Ellipsoid motion, lengthwise, sidewise, random

- a is long axis, b is narrow one
- note a >> b
- say \( b = \frac{a}{10} \)

\[
f_{\text{ellipsoid\_lengthwise}} := \frac{4 \pi \eta a}{\ln \left( 2 \cdot \frac{a}{b} \right) - \frac{1}{2}} \quad \text{f_{ellipsoid\_lengthwise} = } 5.035 \times 10^{-9} \text{ kg/s}
\]

\[
f_{\text{ellipsoid\_sidewise}} := \frac{8 \pi \eta a}{\ln \left( 2 \cdot \frac{a}{b} \right) + \frac{1}{2}} \quad \text{f_{ellipsoid\_sidewise} = } 7.19 \times 10^{-9} \text{ kg/s}
\]

Howard also has tables for rotational drag

**Einstein-Smoluchowski relation**

\[
D_r := \frac{kT}{f_{\text{sphere}}} \quad \text{connects the macroscopic world of diffusion to the microscopic world of frictional drag}
\]

\[
D_r = 2.175 \times 10^{-13} \text{ m}^2/\text{s} \quad \text{this = } 10^{-9} \text{ cm}^2/2
\]

So given a drag relationship, we can use the Einstein relation to determine a diffusion constant

\[
\text{time\_diffuse}(x) := \frac{x^2}{2D_r} \quad \text{time\_diffuse}(10^{-4} \text{ m}) = 2.299 \times 10^4 \text{ s}
\]
Worm Like Chain WLC interpolation

Contour length $L_c := 1500$

Persistence Length $L_p := 53$

$\text{Temp} := 300$

$k := 2 \cdot L_c$

$\text{dis}_k := k - 1$

$F_k := \frac{\text{kt}}{L_p} \left[ \frac{1}{4} \left( 1 - \frac{\text{dis}_k}{L_c} \right)^2 - \frac{1}{4} + \frac{\text{dis}_k}{L_c} \right]$