Terminal Settling Velocity of a Solid Particle in Fluid

Introduction

This application calculates the terminal velocity of a solid particle settling in a fluid.

Deriving the Settling Velocity

```
> restart:
```

Drag force

```
> Fd := 1/2·π·Dia^2/4·CD·ρ_f·v^2:
```

Buoyancy force

```
> Fb := (ρ_p − ρ_f)·g·π·Dia^3/6:
```

The terminal settling velocity is reached when the drag force equals the buoyancy force. Hence, the settling velocity is given by the following equation.

```
> res := v_terminal = solve(Fb = Fd, v)[1]
```

$$res := v_{terminal} = \frac{2\sqrt{-3\,CD\,\rho_f\,g\,Dia\,(\rho_f-\rho_p)}}{3\,CD\,\rho_f} \tag{2.1}$$

Parameters

Gravity:

```
> g := 9.81 m s^-2:
```

Density of the particle:

```
> ρ_p := 1800 kg m^-3:
```

Fluid density:

> $\rho_f := 994.6\,\mathrm{kg\,m^{-3}}$:

Fluid viscosity:

> $\mu := 0.0008931\,\mathrm{Pa\,s}$:

Particle diameter:

> $Dia := 0.000208\,\mathrm{m}$:

Governing Equations

Drag coefficient:

> $$CD := Rey \rightarrow \begin{cases} \frac{24}{Rey} & Rey < 0.1 \\ \frac{24}{Rey}\left(1 + 0.14 \cdot Rey^{0.7}\right) & 0.1 \le Rey \le 1000 \\ 0.44 & 1000 \le Rey \le 350000 \\ 0.19 - \frac{8 \cdot 10^4}{Rey} & Rey > 350000 \end{cases} :$$

> $$ReynoldsNumber := Rey = \frac{Dia\,\rho_f v_{terminal}}{\mu} :$$

> $$TerminalVelocity := v_{terminal} = \sqrt{\frac{4\,g\left(\rho_p - \rho_f\right) Dia}{3\,CD(Rey)\cdot\rho_f}} :$$

Solution

> $fsolve\left(\{ReynoldsNumber, TerminalVelocity\}, \{v_{terminal}, Rey\}\right);$

$$\left\{Rey = 3.656696458,\ v_{terminal} = 0.01578618582\ \frac{\mathrm{m}}{\mathrm{s}}\right\} \qquad \textbf{(5.1)}$$