1D Sedimentation of a sphere

- **Introduction**

This study models the sedimentation of a single spherical particle in a viscous fluid (silicon oil) inside a closed box using an **overset mesh** method. The setup replicates the experiment by ten Cate et al. (2002), where the particle Reynolds number is varied up to ~32 to capture a full range of flow regimes — from creeping to transitional.

- **Simulation Setup**

- **Geometry:**
  - The computational domain consists of a static **background mesh** and a moving **overset mesh** enclosing the sphere.
  - Background mesh size: **cube of length ~133.3 mm**
  - Overset mesh: smaller cube moving with the sphere.
- **Meshing:**
  - blockMesh + snappyHexMesh used to define sphere and background domains.
  - transformPoints used to scale geometry to physical size.
  - topoSet assigns zone IDs (0 for background, 1 for overset).
- **Physics:**
  - **Solver used:** overSedDymFoam_rbgh (includes 6DoF motion).
  - **Motion model:** sixDoFRigidBodyMotionSedFoam
  - The sphere's motion is governed by the balance of buoyancy and drag, with gravity acting downward.
  - The simulation tracks free fall from rest to near-wall interaction.

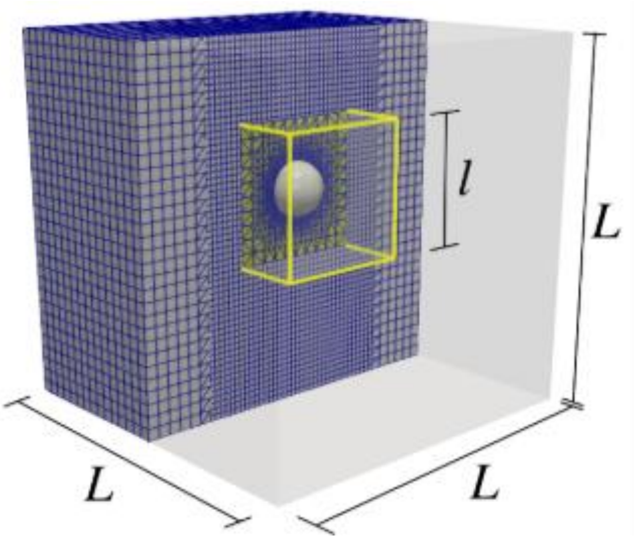

Figure 1: Geometrical domain for the falling sphere using an overset mesh.

➢ Material Properties:

Properties	Value
Sphere density	1120 (kg/m^3)
Fluid Density	970 (kg/m^3)
Fluid Viscosity	3.845E-4 (m^2/s)
Sphere diameter	0.015 m

➢ Simulation Objectives

- Reproduce the **settling dynamics** and **terminal velocity** of the sphere.
- Compare results with benchmark experimental data (ten Cate et al., 2002) and OpenFOAM Wiki reference [(Settling Sphere by Michael Alletto).]()
- Observe flow features: vortex formation, wake symmetry, lubrication effect near bottom wall.

➢ Simulation Results:

The simulation was executed using overSedDyMFoam on 4 cores for a single sphere settling in silicon oil. Below is the result plotted from post-processed Lagrangian data.

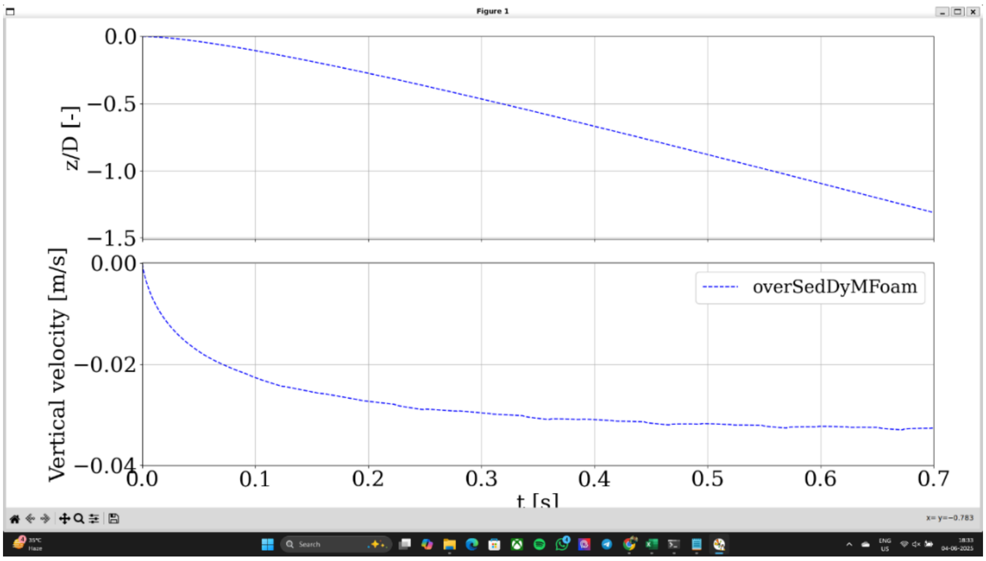

*Figure 2: **Top plot:** Dimensionless position z/D vs time*
Bottom plot: Vertical velocity vs time

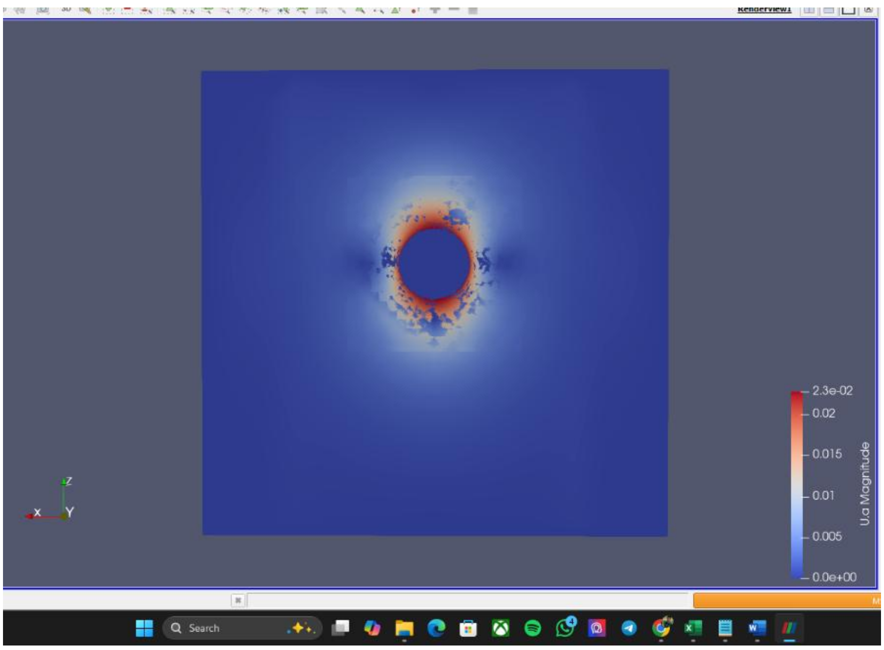

Figure 3: Initial position of the sphere and the fluid interaction

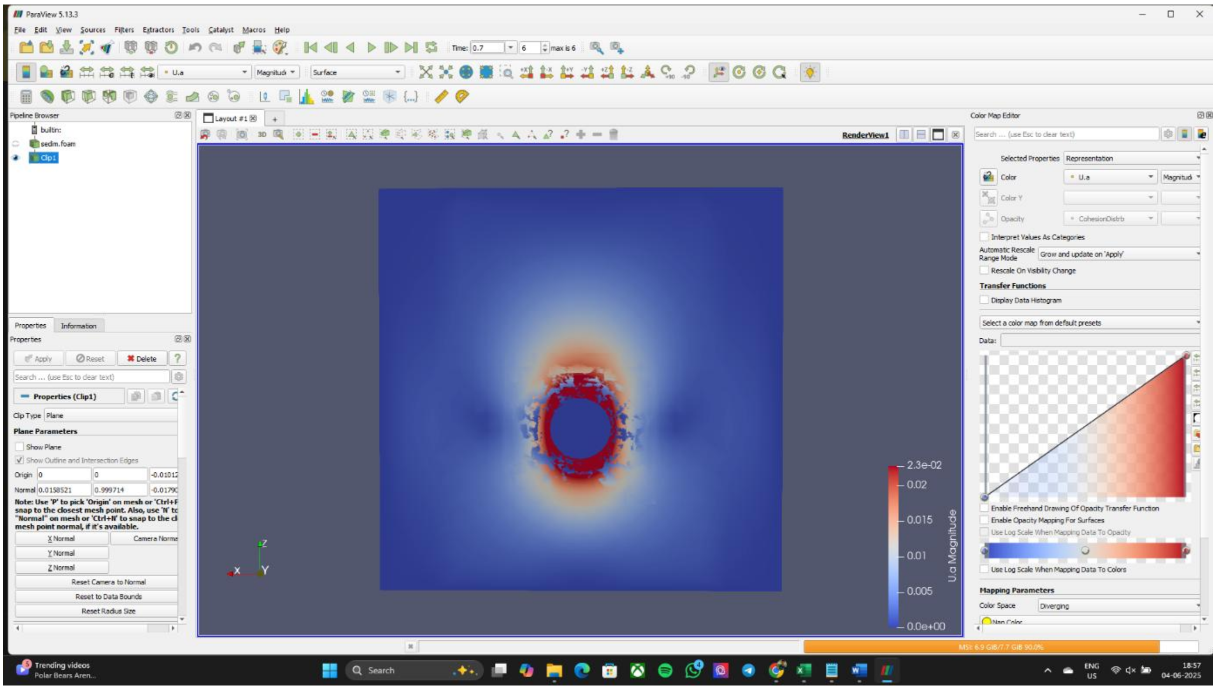

Figure 4: Final position of the sphere and the fluid interaction

➢ Observations

- The **sphere starts from rest** (Vz=0) and accelerates due to gravity.
- **Velocity increases rapidly at first** but quickly reaches a plateau around −0.026m/s, suggesting the approach to terminal velocity.
- The **position curve (z/D)** is smooth and convex, typical of a body accelerating and then entering a steady-fall regime.
- The simulation shows **no significant rebound or oscillation**, consistent with expectations at Reynolds number ≈ 1–5 (as in ten Cate et al., 2002).
- Steady-state appears to be reached around **0.5 seconds**, after which velocity stabilizes, validating the dynamic mesh and 6DoF setup.

➢ Comparison with Literature

As reported by **ten Cate et al. (2002)**:

- For Re ≈ 1.5–4.1, **no rebound** was observed and settling was smooth.
- Velocity profiles match qualitatively with the experiment, where the sphere reached **~90–95% of the theoretical terminal velocity** before wall interaction.