

Sedimentation: Exercise

During the process of sedimentation, the total force exerted on a particle is the result of weight and – in the opposite direction - viscosity and buoyancy.

Given the drag force due to viscosity $F_v = kv$, where v is the velocity of the object and k is a constant depending on the properties of the object and the fluid, what is the total force exerted on the particle?

In equilibrium, the total force is zero and it is possible to calculate the drag velocity of the particle.

Knowing that the gravity acceleration on board the ISS is $g_{ISS} = 10^{-6}g$, calculate the ratio between the drag velocity of the same particle in the same fluid on Earth and on board the ISS.

What happens in an ideal weightless environment?

Solution:

Forces equation on the particle: weight, buoyancy, drag force

$$F_{tot} = +mg - kv - \rho gV = \rho_p gV - kv - \rho gV$$

m = mass of the particle

ρ = fluid density

ρ_p = particle density

V = volume of the particle

At equilibrium $F_{tot} = 0$ and

$$v = g(\rho_p - \rho)V/k$$

In the same conditions, $v_{ISS}/v_{EARTH} = g_{ISS}/g = 10^{-6}$. This means that if a particle takes 10 seconds to fall from one point to another on ground, it will cover the same path in 10,000,000 seconds on board the ISS. That is, particles sediment so slowly that the solution can be considered stable.

In weightlessness, particles in a fluid do not move under their weight and the entire process of sedimentation does not occur.