Brownian Motion versus Settling: Particle Size Where They Match

Particle size at which Brownian displacement equals Stokes settling in a given time, and both distances for a chosen particle size in water.

Method: Stokes' law and Stokes–Einstein Brownian displacement (2Dt)^½

Input parameters

Unit system: SI

Parameter	Value	Unit
Particle density	2,000.0	kg/m³
Water density	999.10	kg/m³
Water viscosity	1.1380	mPa·s
Water temperature	15.000	°C
Time	1.0000	s
Particle diameter to examine	0.50000	µm

Calculated results

Parameter	Value	Unit
Size at which Brownian and settling distances match	1.2643	µm
Settling distance of the chosen particle	0.11979	µm
Brownian displacement of the chosen particle	1.2181	µm
Brownian to settling ratio	10.168	
Particle diffusivity (Stokes–Einstein)	7.4185e-13	m²/s

Notes for this case

- Brownian displacement x_B = (2Dt)^½ with D = kT/(3πµd_p), settling by Stokes' law. Particles much smaller than d_p,eq stay suspended by Brownian motion and do not settle in practical times.

Formula and method

$$d_{p,eq} = \left[\frac{216\,kT\mu}{\pi g^2(\rho_p-\rho_w)^2 t}\right]^{1/5}$$

$$x_s = \frac{g(\rho_p-\rho_w)d_p^2}{18\mu}t, \quad x_B = \sqrt{2Dt}, \quad D = \frac{kT}{3\pi\mu d_p}$$

Variables

ρ_p	Particle density	kg/m³
ρ_w	Water density	kg/m³
μ	Water viscosity	Pa·s
T	Water temperature	K
t	Time	s
d_p	Particle diameter to examine	m
$d_{p,eq}$	Size at which Brownian and settling distances match	m
x_s	Settling distance of the chosen particle	m
x_B	Brownian displacement of the chosen particle	m

x_B/x_s	Brownian to settling ratio	-
D	Particle diffusivity (Stokes–Einstein)	m²/s

Method and standards

Comparison of Stokes settling with Brownian displacement of spherical particles.

Assumptions and limits

- Spheres, Stokes regime, dilute suspension.

References

Stokes' law and Stokes–Einstein Brownian displacement (2Dt)^½

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/environmental/drinking-water/brownian-motion-settling-size

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.