

Table 2: Formal Convergence Verification — GCI Method (Celik et al. 2008)

Metric	Triplet dp	r_{21}	r_{32}	Type	ρ_{app}	ϕ_{ext}	GCI_{fine}	AR	Verdict
Displacement	0.005, 0.008, 0.015	1.60	1.88	Monotonic D	—	—	U=0.9	— NOT	CONVERGE
SPH Force	0.005, 0.008, 0.015	1.60	1.88	Monotonic D	—	—	U=71.7	— NOT	CONVERGE
Velocity	0.005, 0.008, 0.015	1.60	1.88	Oscillatory	—	—	U=0.1	— NOT	CONVERGE
Rotation	0.005, 0.008, 0.015	1.60	1.88	Monotonic D	—	—	U=18.4	— NOT	CONVERGE
Contact Force	0.005, 0.008, 0.015	1.60	1.88	Monotonic D	—	—	U=2392.1	— NOT	CONVERGE
Flow Velocity	0.005, 0.008, 0.015	1.60	1.88	Oscillatory	—	—	U=0.1	— NOT	CONVERGE