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Effect of particle moment of inertia on the dynamics and wakes of freely rising cylinders VARGHESE MATHAI, XIAOJUE ZHU, Univ of Twente, CHAO SUN, Tsinghua University, DETLEF LOHSE, Univ of Twente — We perform a numerical study on the two-dimensional motions and wakes of freely rising and falling circular cylinders in quiescent fluid. We show that the amplitude of oscillation and the overall system-dynamics are intricately linked to two parameters: the particle's mass-density relative to the fluid $m^* \equiv \rho_p/\rho_f$, and its relative moment-of-inertia $I^* \equiv I_p/I_f$. Using over 144 combinations of m^* and I^*, we comprehensively map out the parameter space covering very heavy ($m^* > 10$) to very buoyant ($m^* < 0.1$) particles at fixed Galileo number (Ga = 500). The entire data collapses into two scaling regimes demarcated by a transitional Strouhal number, $St_t \approx 0.17$. St_t separates a mass-dominated regime from a regime dominated by the particle's moment of inertia. A shift from one regime to the other also marks a gradual transition in the wake-shedding pattern: from the classical $2S$ (2-Single) vortex mode to a $2P$ (2-Pairs) mode of wake vortices. Thus, autorotation, triggered by moment of inertia reduction, can significantly enhance the translational oscillations of freely rising isotropic bodies.

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