Dynamics and wake patterns of freely rising and falling spheres
at Re = 500 M. HOROWITZ, C.H.K. WILLIAMSON, Cornell University — We
study the dynamics of spheres rising or falling freely at Re = 500. All falling spheres,
whose mass ratio (or relative density) m*, exceeds 1, descended rectilinearly. For
rising spheres, there exists a critical value of the mass ratio below which the sphere
undergoes large-amplitude oscillations, m*crit = 0.36. This motion occurs in a ver-
tical plane; no helical trajectories are observed. Initial wake visualizations showed
that rather than the two alternately signed vortex loops found in the flow past sta-
tionary spheres, the wake of a vibrating freely rising sphere comprised four vortex
structures per cycle of oscillation. However, due to the small size and high oscilla-
tion frequency of the freely rising spheres, the exact nature and formation of these
structures remained unclear. Further studies were performed in a towing tank, pre-
scribing the motion of the sphere based on the measured displacement of the rising
spheres. We are able to use much larger, slower-moving bodies while matching the
Reynolds numbers of the rising spheres. These experiments result in the same vor-
tex pattern, and reveal that the four structures found in the wake of the rising
sphere are vortex rings. What previously appeared to be unusually sharp bends in
the counter-rotating vortex pairs are very weak loop-shaped structures, delivering
a total of six vortical structures per cycle. Immediately preceding these structures,
the two vortices in the pair cross over one another, providing a mechanism for the
change in sign of the streamwise vortex pair as the body moves from one half cycle
to the next.

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