Flows of normal and superfluid $^4$He (He I and He II, respectively) are investigated experimentally. Relatively small particles of solid hydrogen and deuterium are suspended in the experimental volume and their motions are tracked in both mechanically and thermally driven flows. A statistical study of the particle velocity and velocity increment distributions is performed at scales smaller and larger than the mean distance between quantized vortices, the quantum length scale of the investigated flows. We show that, at small scales, the observed particle dynamics in He II is greatly influenced by that of quantized vortices. We, additionally, report that this behavior is independent of the imposed large-scale flow. Instead, at large scales, we observe that particle motions are quasiclassical, that is, very similar to those reported to occur in turbulent flows of viscous fluids. The study reinforces therefore the idea of close similarity between viscous flows and large-scale (mechanically-driven) flows of He II, and simultaneously highlights the small-scale differences due to the presence of quantized vortices in He II.