Residence time of a buoyant ball in a hydraulic jump

RICHARD KEANE, MICHAEL DAMERON, GUSTAVO GIOIA, PINAKI CHAKRABORTY,
University of Illinois at Urbana-Champaign — We study experimentally the residence time required for a buoyant ball to cross upstream of a hydraulic jump. The experimental results indicate that the distribution of residence times is exponential, and therefore history-independent. Based on this insight, we formulate a model in which an attempt at crossing the hydraulic jump is made at regular time intervals $\tau$ and with a constant probability of success $p$, use phenomenological theory of turbulence to obtain an expression for $\tau$, and ascertain that $p$ depends on a single dimensionless variable, which we identify. Last, we show that the predictions of this model are in good accord by the experimental data over a broad range of Froude numbers, ball sizes, and ball densities.