Comment on "Measurement of Gravitational Acceleration Using Bernoulli's Equation"

Letter to the Editor:
Comment on "Measurement of Gravitational Acceleration Using Bernoulli's Equation" by T. Jang et al. (*Phys. Teach*. 62, 268–271, 2024)

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We read the paper by Jang et al. [1] with great interest. The authors describe two elementary experiments for measuring the gravitation acceleration. The experiments are based on a jet of water flowing out of a hole in a tank. The authors concluded that their Experiment II was less accurate than their Experiment I. Here, we show that Experiment II gives results quite close to Experiment I if the data are reduced differently.

Experiment II requires a value for the velocity coefficient of a sharp-edged orifice, c_v. The authors cite our 1984 paper [2], which applies viscous fluid flow principles to show that c_v is very nearly equal to one. In other words, $c_v \cong 1$. We discussed in detail why the historical value of $c_v = 0.98$ is not correct. So, we were surprised that the authors used $c_v = 0.98$ (from a handbook) to reduce the data in Experiment II.

How does the difference in c_v affect the results? From equation (16), the experimental value of g is proportional to $(c_v)^{-2}$. If we take $c_v = 1$, instead of $c_v = 0.98$, the reported experimental values (10.11 and 10.18 m^2/s) are reduced to 9.71 and 9.78 m^2/s. The reduced values differ from the official value in Daegu province ($g = 9.7981$ m^2/s) by only −0.9% and −0.04%. Thus, Experiment II yields results comparable to Experiment I (9.84 ± 0.19 m^2/s).

Our paper focused on laminar boundary layer theory, so it is understandable that the authors may have preferred the handbook value of c_v. However, the data from Experiment II should be reduced using $c_v = 1$. With the correct c_v, the experiments introduced by Jang et al. provide an excellent introduction to several aspects of elementary physics.

References:
[1] T. Jang et al., "Measurement of Gravitational Acceleration Using Bernoulli's Equation," *Phys. Teach*. 62, 268–271 (2024).
[2] J.H. Lienhard, V and J.H. Lienhard, IV, "Velocity coefficients for free jets from sharp-edged orifices,'' *J. Fluids Engineering*, 106, 13–17, (1984).