Bob Pendulum Oscillation Under Air Flow: An Experimental and Numerical Investigation

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Although the oscillation of a pendulum in static air has been studied well both theoretically and experimentally, the influence of external forces such as airflow or wind has received less attention. To address this gap, this study investigated the motions of a spherical bob pendulum when perturbed by air currents and constant velocity in a 2D plane. This involved finding a differential equation of motion by using the torque equation, then analyzing the stability by linearization of the system. We conducted an experiment to find the relationship between wind forces at different wind speeds at the equilibrium position, then found the 2nd order polynomial equation to determine drag coefficient and viscosity coefficient. After that, we created a numerical model on Wolfram Mathematica and used Tracker to perform motion tracking of the pendulum motion in the air tunnel with 3.38 m/s wind speed. Finally, we compared and analyzed the graph characteristics obtained from the mathematical model with the motion tracking results and the stability analysis results. All three methods yielded similar results. The pendulum motion under airflow was stable, with the topology being in the form of an inward spiral or sink. Constant air currents resisted motion and drove the system to the critical point at an angular velocity of 0 rad/s and a constant angle (above 0 rad). It can be concluded that the motion is damped oscillation.

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