Theory and Experiments of Damped Oscillation With Sliding Friction

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My research interest has expanded from simple harmonic oscillations to include various forms of damped oscillatory systems. Just as the oscillation of a building during an earthquake or a swinging pendulum gradually subsides, damped oscillations are observed in various physical systems. In this study, damped oscillations subjected to sliding friction were investigated both theoretically and experimentally. When conducting an experiment on damped oscillation of a spring-mass system under the influence of sliding friction, the observed damping curve did not perfectly follow an exponential function, suggesting that the damping was caused by both viscous resistance and sliding friction. To enhance our comprehension of the system's behavior, a mathematical expression that accurately describes the displacement of damped oscillation due to viscous resistance and Coulomb friction was derived from the equation of motion, and the resulting formulas were plotted. The model was constructed using a recurrence relation, based on the fact that the displacement reaches an extremum and remains continuous at that moment, when the direction of Coulomb friction reverses with motion. The model predictions are consistent with the experimental findings. In addition, the damping curve formula was used in data analysis to determine the damping rate and magnitude of the sliding friction force. These results indicate that air resistance is negligible, and the primary sources of damping are the internal viscosity of the spring and sliding friction. This research has potential applications in oscillation control and earthquake resistance technologies, such as a sliding seismic isolation mechanism.

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