Harmonic Oscillation in the Presence of Multiple Damping Forces

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HARMONIC OSCILLATION IN THE PRESENCE OF MULTIPLE DAMPING FORCES

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The relatively mundane damped harmonic oscillator is found to exhibit interesting motion once under the influence of both a velocity dependent and Coulombic frictional damping force. Data for the decay of the amplitude as a function of time were collected on a specially prepared torsional oscillator with a variable electromagnetic damping mechanism. An analytical solution of the appropriate equation of motion was obtained by the method of Laplace transforms. In both the limits of zero Coulombic friction and zero velocity damping, the solution reduces to the well-known answers to the problem. The solution, when plotted with the correct parameters, fits the numerical solution very well and shows some quantitative agreement with the experimental data.

Scientists and engineers deal with damped oscillating systems on a regular basis. Damping in real world systems is understood in the limiting cases of dominant Coulombic friction and dominant velocity-dependent damping, but the regime encountered when both types of damping are present is not as well understood. The solution which we have found provides an analytic means of modelling a real world system in a regime previously requiring numerical methods of solution. This solution will be immediately useful to several types of scientists, because the harmonic oscillator is found in fields ranging from physics and engineering to chemistry. The solution is likely to be most useful in the field of mechanical engineering, because no electrical analog of Coulombic friction is known to exist. This solution also has significant pedagogical implications, since it addresses a problem which has been ignored in textbooks. All undergraduate texts include the familiar problem of a harmonic oscillator which is experiencing velocity damping, and a few level texts include the case of Coulombic friction damping. The case when both are present has been overlooked, presumably because an analytic solution was not available. The present work advances our understanding of a common physical phenomenon.