VIBRATIONS OF A COULOMB DAMPED HELICAL SPRING,  
A FINITE ELEMENT APPROACH

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ABSTRACT

This thesis examines the dynamic behavior of a helical spring under a sinusoidal excitation induced by a rotating cam. One end of the spring is fixed, and its free end follows the cam motion. The spring is sleeved over a mandrel, thereby is further subjected to a Coulomb Damping during its oscillations.

Helical springs expand radially when they are compressed. If a friction surface is in contact with the inner surface of the spring, the radial expansion reduces the damping force to a minimum level at the maximum compressed displacement imposed by the cam.

Standard wave equation that includes damping was used to examine the vibratory behavior of the spring. A numerical solution to the no friction, constant friction, and varying friction forces was obtained from the wave equation using Explicit Finite Difference Method. A distributed parametric model using an explicit finite difference routine was used to obtain numerical solutions for the damped cases. A Finite Element Analysis package called “Algor” was used to model the radial expansion of the spring for determining the variations of the Coulomb friction force as the result of this radial expansion. “Visual Fortran” was employed to integrate the hyperbolic partial differential
equations of motion governing the dynamics of the spring in response to the cam excitation.

The spring response to the prescribed cam excitation, under the variable Coulomb friction force, was found to be different than that of a previously assumed constant friction force. This work demonstrates the importance of considering the dynamic effects for a safe and reliable design of valve springs, but also provided a tool for the evaluation of various designs.