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Attenuation of a linear oscillator using a nonlinear and a semi-active tuned mass damper in series

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Abstract: Auxiliary absorbers provide an effective means to attenuate the vibrations of a structural or mechanical system (the "primary structure"). The simplest auxiliary absorber, a tuned mass damper (TMD), provides reliable narrow-band attenuation but is not robust to the effects of detuning. Strongly nonlinear tuned mass dampers (NTMDs) are capable of wide-band, irreversible energy transfer known as "energy pumping" but can also exhibit detached high-amplitude solutions which can significantly amplify the response of the primary structure. Semi-active tuned mass dampers (STMDs) incorporate an actuating element in order to achieve real-time tuning adjustment capability. This talk presents a global dynamic analysis of the response of a primary structure with an NTMD, and then explores the performance of a novel absorber configuration consisting of an NTMD and STMD attached to the primary structure in series. The global dynamic analysis is conducted using a new cell mapping method: the parallelized multi-degrees-of-freedom cell mapping (PMDCM) method. The benefits of the additional STMD component are explored for two distinct applications: (1) restoring the performance of a linear TMD which develops a weak nonlinearity due to operation outside of the intended range or other means, and (2) acting as a safety device to eliminate or minimize convergence to the detached high-amplitude response. In the weakly nonlinear case, the STMD is shown to reduce the effects of the nonlinearity and improve attenuation capability by constraining the motion of the NTMD. In the strongly nonlinear case, the STMD effectively eliminates the complex response behavior and multiple solutions which were present in the original system, resulting in a single low-amplitude response. Experimental tests using an adaptable-length pendulum STMD verify the numerical results.

Biography: Dr. Dick received his B.S. and M.S. through an accelerated dual degree program at the Rochester Institute of Technology in Rochester, New York. He received his Ph.D. from the University of Maryland, College Park. He is an NSF Fellow and a member of the American Society of Mechanical Engineers (ASME).