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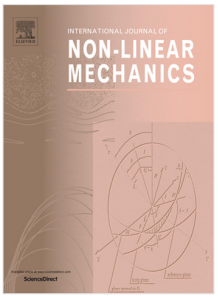

On the response of some discrete and continuous oscillatory systems with pure cubic nonlinearity: Exact solutions

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On the response of some discrete and continuous oscillatory systems with pure cubic nonlinearity: exact solutions

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Abstract

This study is concerned with oscillatory systems with pure cubic nonlinearity, which are systematically presented, starting from a one degree of freedom oscillator, then focusing on chains with two and multi degrees of freedom, and ending with elastic systems (systems having an infinite number degrees of freedom). A one degree of freedom pure cubic oscillator is given as a reference case for the other systems under consideration as it has the exact closed-form solution for its free response. Similar normal modes and exact solutions for free response are investigated in chains consisting of two discrete masses attached with pure cubic springs in two configurations: when anchored at both ends, and anchored at one end only. The former class is exhibits a pitchfork bifurcation related to their similar normal modes and the way how this bifurcation is created and destroyed is demonstrated in terms of stiffness ratios. These chains are then enhanced with additional masses and springs of the same stiffness, and their similar normal modes are determined (modal shapes, frequencies and the exact closed-form solution for time responses). Finally, longitudinal vibration of a bar with a pure cubic relationship between the axial stress and strain are examined analytically, obtaining the exact solution for the first mode shape of a clamped-clamped and clamped-free bar. Their first modes are compared with those obtained for nonlinear chains with multiple masses as well as with the well-known results for linear longitudinal vibration of the bars with the same boundary conditions.

Keywords: pure cubic spring; exact solution; chain; similar normal modes; longitudinal