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Accurate approximations of the nonlinear vibration of couple-mass-spring systems with linear and nonlinear stiffnesses

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Abstract
An analytical technique has been developed based on the harmonic balance method to obtain approximate angular frequencies. This technique also offers the periodic solutions to the nonlinear free vibration of a conservative, couple-mass-spring system having linear and nonlinear stiffnesses with cubic nonlinearity. Two real-world cases of these systems are analysed and introduced. After applying the harmonic balance method, a set of complicated higher-order nonlinear algebraic equations are obtained. Analytical investigation of the complicated higher-order nonlinear algebraic equations is cumbersome, especially in the case when the vibration amplitude of the oscillation is large. The proposed technique overcomes this limitation to utilize the iterative method based on the homotopy perturbation method. This produces desired results for small as well as large values of vibration amplitude of the oscillation. In addition, a suitable truncation principle has been used in which the solution achieves better results than existing solutions. Comparing with published results and the exact ones, the approximated angular frequencies and corresponding periodic solutions show excellent agreement. This proposed technique provides results of high accuracy and a simple solution procedure. It could be widely applicable to other nonlinear oscillatory problems arising in science and engineering. © The Author(s) 2019.

Author Keywords
couple-mass-spring systems; Duffing equation; harmonic balance method; homotopy perturbation method; iterative method; Nonlinear stiffnesses; two-degree-of-freedom oscillation systems

Index Keywords
Algebra, Control nonlinearities, Degrees of freedom (mechanics), Harmonic analysis, Iterative methods, Perturbation techniques, Stiffness, Vibration analysis; Duffing equations, Harmonic Balance method, Homotopy Perturbation Method (HPM), Mass spring systems, Non-linear stiffness, Oscillation system; Nonlinear equations

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