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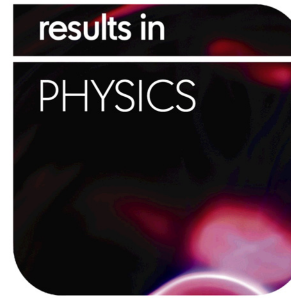

Modified Multiple Time Scale Method for Solving Strongly Nonlinear Damped Forced Vibration Systems

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Abstract

In this paper, modified multiple time scale (MTS) method is employed to solve strongly nonlinear forced vibration systems. The first-order approximation is only considered in order to avoid complexicitiy. The formulations and the determination of the solution procedure are very easy and straightforward. The classical multiple time scale (MS) and multiple scales Lindstedt-Poincare method (MSLP) do not give desire result for the strongly damped forced vibration systems with strong damping effects. The main aim of this paper is to remove these limitations. Two examples are considered to illustrate the effectiveness and convenience of the present procedure. The approximate external frequencies and the corresponding approximate solutions are determined by the present method. The results give good coincidence with corresponding numerical solution (considered to be exact) and also provide better result than other existing results. For weak nonlinearities with weak damping effect, the absolute relative error measures (first-order approximate external frequency) in this paper is only 0.07% when amplitude $A = 1.5$, while the relative error gives MSLP method is surprisingly 28.81%. Furthermore, for strong nonlinearities with strong damping effect, the absolute relative error found in this article is only 0.02%, whereas the relative error obtained by MSLP method is 24.18%. Therefore, the present method is not only valid for weakly nonlinear damped forced systems, but also gives better result for strongly nonlinear systems with both small and strong damping effect.

Keywords: Nonlinear oscillations; Duffing equation; Van der Pol equation; Struble's technique; Multiple time scale method.

Nomenclature

ω_0	Natural frequency
k	Linear damping coefficient
ν	The external frequency
a	Amplitude
E	An external force
Φ	Periodic function
ε	A large or small parameter
φ	Phase variable
ψ	Phase variable chosen in our method