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Asymptotic approach to the nonlinear dynamical problems

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Nonlinarity is a common feature of many mechanical systems. Although in many tasks the linear approximation is sufficient, there are numerous problems where neglecting nonlinear effects leads to incorrect solutions. In most cases the nonlinear systems are investigated numerically. However, numerical studies may be insufficient for the comprehensive understanding of the complicated dynamical behavior. In the numerical approach, calculations have to be performed for an established set of parameters and initial conditions. For that reason the important phenomena occurring for only narrow range of some parameter could be omitted and unnoticed. On the other hand, the analytical approach allows to obtain a solution as a function of some parameters which gives the opportunity to discuss results for wide spectrum of parameters.

Usually, analytical exact solution of the nonlinear equations of motion cannot be obtained. The main goal of the paper is to show how the approximate analytical solution of the steady and non-steady state of motion can be obtained for some lumped mass (discrete) nonlinear systems. The asymptotic multiple scale method (MSM) is used to solve the initial value problems [1, 2, 4].

The dynamical analysis of two nonlinear systems are presented in the paper. The first deals with a nonlinear spring pendulum, which though quite simple, may serve as a good example for study non-linear phenomena appearing in numerous mechanical systems governed by ordinary differential equations. The steady and non-steady vibrations are discussed, both far from resonance as well as near resonance when intensive energy exchange between the system and external source or between parts of the investigated system are observed. These phenomena are widely illustrated and discussed in references [3, 4].

The second system discussed in the paper is micro torsional resonator which plays a crucial part of the MEMS gyroscope. In the latter case, a resonance phenomenon is the desirable state of its working regime. The nonlinear elastic properties of the suspension affect the resonance response, so the appropriate analytical approach is necessary to get reliable and validated results.

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