

Higher-order linear and nonlinear differential equations

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Abstract

In this contribution, we prove the existence of an exact harmonic solution for higher-order linear and nonlinear differential equations via the harmonic oscillator.

Keywords: harmonic oscillator, higher-order linear differential equation, higher-order nonlinear differential equation, exact harmonic solution.

Introduction

Although higher-order autonomous ordinary differential equations have been widely investigated, Adjai and coworkers [1] were the first authors to explicitly and exactly prove the existence of an exact harmonic periodic solution for higher-order nonlinear equations. In this sense, Akande et al. [2] recently proved the existence of conservative nonlinear oscillators of higher order with exact harmonic solutions. In a recent paper [3], the authors showed the existence of nonlinear $(n+2)th$ order differential equations via the harmonic oscillator and the Ermakov-Pinney system with an exact periodic solution. In this contribution, the question is to ask to find higher-order linear and nonlinear differential equations that can admit an exact harmonic solution. To show that higher-order linear systems can exhibit an exact sinusoidal periodic solution, consider the following existence result that can be proven.

Theorem 1. Let

$$\frac{d}{dt} \dot{x} + \beta \frac{d^n}{dt^n} (\ddot{x} + x) + x = 0, \quad (1)$$

where β is a constant and the overdot indicates the differentiation with respect to time. Then, equation (1) admits the exact sinusoidal solution

$$x(t) = \cos t. \quad (2)$$

Remark 1. Equation (1) is a linear $(n+2)th$ order differential equation. For example, if

$n = 1$, equation (1) is reduced to [4]

$$\beta \ddot{x} + \dot{x} + \beta \dot{x} + x = 0. \quad (3)$$

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Nonlinear Differential Equations Of Higher Order

Santanu Saha Ray



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