
# A novel approach for free vibration of axially functionally graded beams with non-uniform cross-section based on Chebyshev polynomials theory

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# A novel approach for free vibration of axially functionally graded beams with non-uniform cross-section based on Chebyshev polynomials theory

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**Abstract**

A new approach based on Chebyshev polynomials theory is introduced to analyze free vibration of axially functionally graded Euler-Bernoulli and Timoshenko beams with non-uniform cross-sections. By using high-order Chebyshev expansions to approximate deflections of a beam, its potential energy and kinetic energy, both of which can be considered as weighted inner products of functions, can be expressed in matrix form. All variable geometric and material properties, such as cross-sectional area, area moment of inertia, mass density, Young's modulus, and shear modulus, are treated as weight functions. In this way, the discrete governing equation can be obtained directly by applying Lagrange's equation. Natural frequencies and mode shapes can be easily determined by solving the eigenvalue equation. Several numerical examples are carried out to verify the competency of the proposed method. All results are seen to be in excellent agreement with those presented in literature. The overall convergence is approximately exponential, and a highly accurate solution can be gained by using a small number of polynomials.

*Keywords:* Functionally graded beam, Chebyshev polynomials, Vibration, Natural frequency

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