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### عنوان مقاله:

Theoretical Formulations for Finite Element Models of Functionally Graded Beams with Piezoelectric Layers

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### خلاصه مقاله:

In this paper an overview of functionally graded materials and constitutive relations of electro elasticity for threedimensional deformable solids is presented, and governing equations of the Bernoulli-Euler and Timoshenko beam theories which account for through-thickness power-law variation of a two-constituent material and piezoelectric layers are developed using the principle of virtual displacements. The formulation is based on a power-law variation of the material in the core with piezoelectric layers at the top and bottom. Virtual work statements of the two theories are also developed and their finite element models are presented. The theoretical formulations and finite element models .presented herein can be used in the analysis of piezolaminated and adaptive structures such as beams and plates

## کلمات کلیدی:

Bending, Bernoulli-Euler beam theory, Functionally graded material, Piezoelectricity, PZT, Timoshenko Beam Theory

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