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A variational formulation of nanoscale beam bending

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Several past studies have applied the Gurtin-Murdoch continuum theory to analyze nanobeams by adding the distributed vertical loading induced by surface tension to the classical beam bending model with modified beam stiffness. One of these solutions showed that a cantilever is softer whereas a simply-supported or fixed-fixed beam is stiffer compared to a classical beam when surface residual stress is positive. A more recent solution for nanobeams is also based on Gurtin-Murdoch theory but used the equilibrium and full elastic field. However, this solution showed that all beams are stiffer compared to the corresponding classical cases under positive surface residual stress. The objective of this paper is to investigate this discrepancy. The governing equation and admissible boundary conditions are re-derived using a variational method. The root cause of discrepancy is attributed to inconsistent boundary conditions in the earlier solutions. Several interesting features of nanobeam continuum modeling are discussed.

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