



MECHANICAL ENGINEERING MSc SEMINAR (30 min.)

Monday, July 13 2026 at 16:00-16:30, Lady Davis Building, Room 451

The behaviour of elastica-based bistable element: Analytical approach

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Bistable elements are highly valuable for applications involving mechanical memory, switches, and multi-stable metamaterials designed for advanced energy absorption. Although the double-beam element is a standard design for bistable springs, a closed-form analytical characterization linking its bistable behavior to specific geometrical and material properties is currently lacking. This work addresses this gap by developing a complete analytical description based on the inextensible inflectional elastica. The non-linear large deflections of the beam are modeled as a boundary value problem constrained by tip location, and exact analytical solutions are derived utilizing Jacobi elliptic functions. This mathematical approach mirrors the closed-form elastica frameworks recently utilized to formulate stability and optimal control criteria for flexible linear objects in advanced robotic manipulation.

By analyzing the phase space - which is mathematically identical to the pendulum equation - two primary solution types are identified: Periodic Elastica Solutions (PES) and Symmetric Elastica Solutions (SES). To validate the physical viability of these solution branches, structural stability is evaluated using the second variation of calculus of variations and the MORSE theorem. The analytical stability boundaries, verified against discretized numerical eigenvalue analysis, reveal strict stability thresholds. Additionally, investigation of the double-well potential structure confirms that system energy is uniquely dependent on the chosen solution branch. This comprehensive analytical framework lays the groundwork for generating precise force-displacement curves and offers actionable design guidelines for tuning bistable properties through geometric and material selection.