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EE C247B - ME C218 Introduction to MEMS Design Spring 2016

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Lecture Module 8: Microstructural Elements

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Outline

- Reading: Senturia, Chpt. 9
- Lecture Topics:
 - ↪ Bending of beams
 - ↪ Cantilever beam under small deflections
 - ↪ Combining cantilevers in series and parallel
 - ↪ Folded suspensions
 - ↪ Design implications of residual stress and stress gradients

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Bending of Beams

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Beams: The Springs of Most MEMS

- Springs and suspensions very common in MEMS
 - ↪ Coils are popular in the macro-world; but not easy to make in the micro-world
 - ↪ Beams: simpler to fabricate and analyze; become "stronger" on the micro-scale → use beams for MEMS

Comb-Driven Folded Beam Actuator

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Bending a Cantilever Beam

Clamped end condition:
At $x=0$:
 $y=0$
 $dy/dx = 0$

Free end condition

Objective: Find relation between tip deflection $y(x=L_c)$ and applied load F

Assumptions:

1. Tip deflection is small compared with beam length
2. Plane sections (normal to beam's axis) remain plane and normal during bending, i.e., "pure bending"
3. Shear stresses are negligible

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Reaction Forces and Moments

Reaction Moment $M_R = M_1$

Point Load F

Moment due to F, here:
 $M_1 = FL$

Moment due to F, here:
 $M_2 = F(L-x)$

Reaction Force $F_R = F$

split

Reactions (Senturia gives expressions)

For equilibrium: $M_{x,r} = M_3 = F(L-x)$
 $V_{x,r} = F$

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Sign Conventions for Moments & Shear Forces

Positive **Negative**

Moment

(+) moment leads to deformation with a (+) radius of curvature (i.e., upwards)

(-) moment leads to deformation with a (-) radius of curvature (i.e., downwards)

Shear

(+) shear forces produce clockwise rotation

(-) shear forces produce counter-clockwise rotation

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