

EXTENDING emstatic.m TO 2D STRUCTURES

Project

Micro and Nano Mechanics (NE211)

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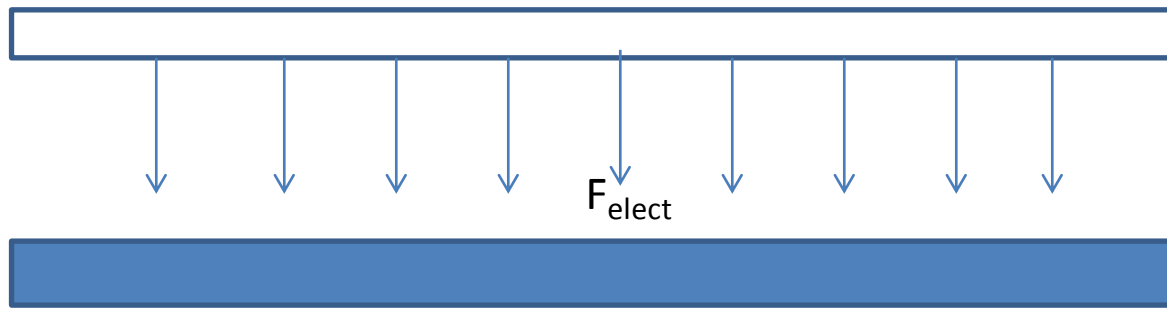
AIM

- `emstatic.m` is demonstration of Electrostatic – Elastostatic domain coupling and Pull-in phenomenon, using parallel plate approximation
- `emstatic2D.m` calculates deformation of 2D beam structure, and Pull-in by solving coupled Electrostatic-Elastostatic equation

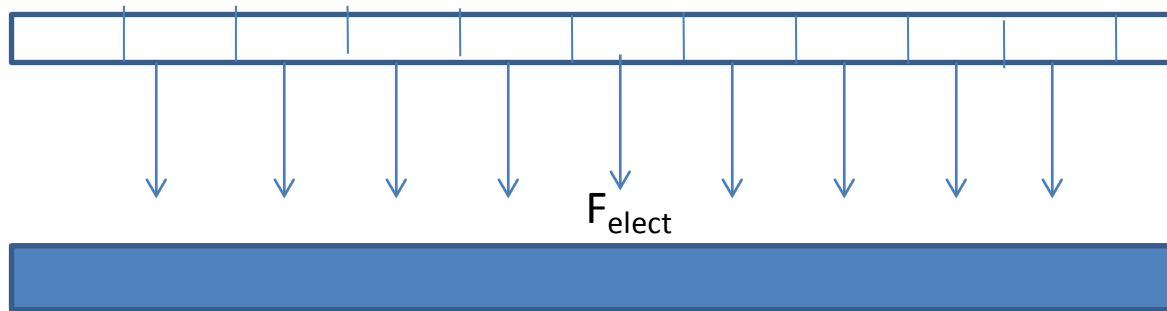
CONSTRAINTS IMPOSED

- Electrodes and beams can be oriented in any direction, but Electrodes are parallel to beam
- Parallel Plate Approximation is used to calculate electrostatic force on a small beam element
- All Forces are assumed to act at the nodes

Nmax = maximum number of nodes in the structure, is taken 100 in this code
If more nodes are present, change Nmax value
Nmax used in discriminating end nodes



The emstatic2D splits the beam into many small beams internally



The distributed electric force is taken as lumped force on the small beam segments' nodes

Governing Equation

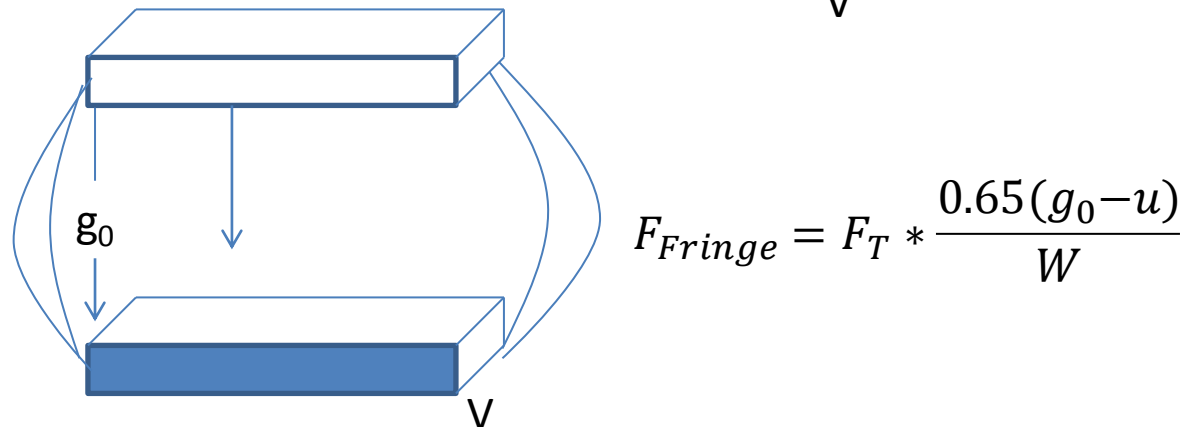
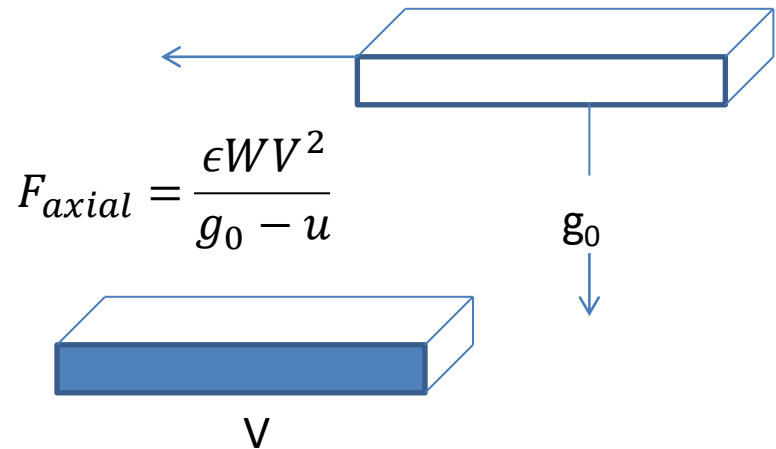
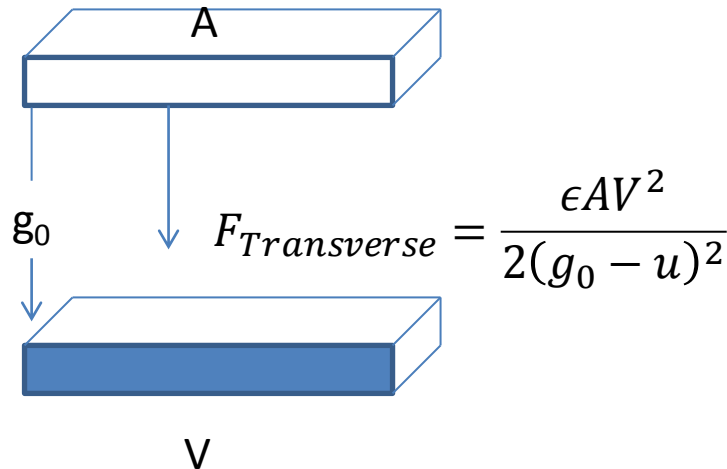
$$\frac{d}{dx} EI \frac{d^2 w}{dx^2} = F(x)$$

E = Young's Modulus

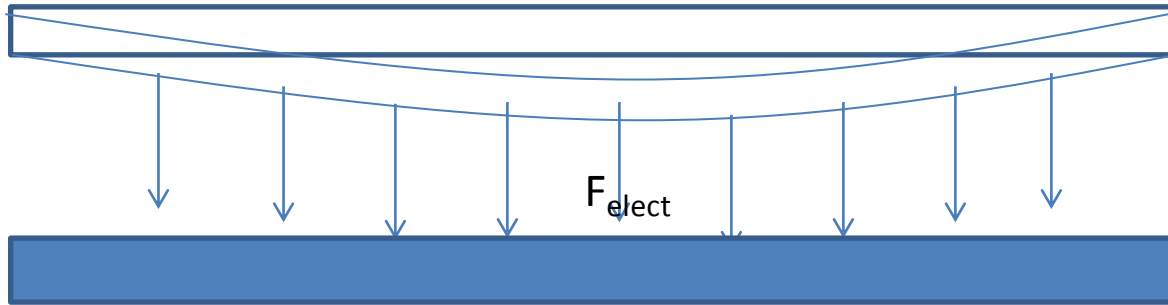
I = Moment of Inertia

F = Force at the beam nodes

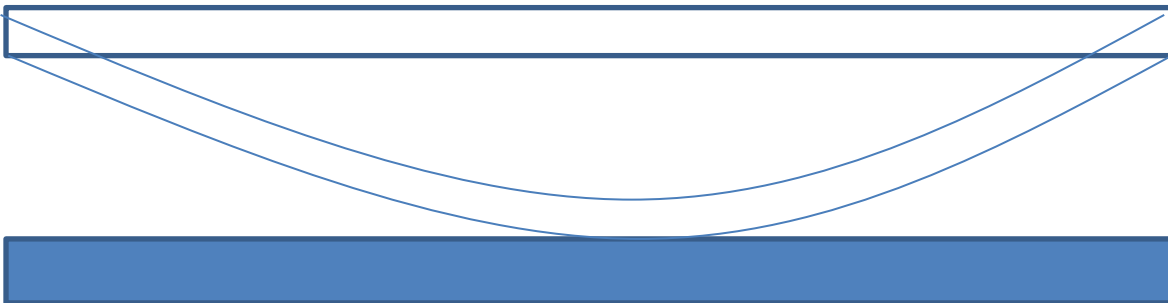
W = Beam Shape



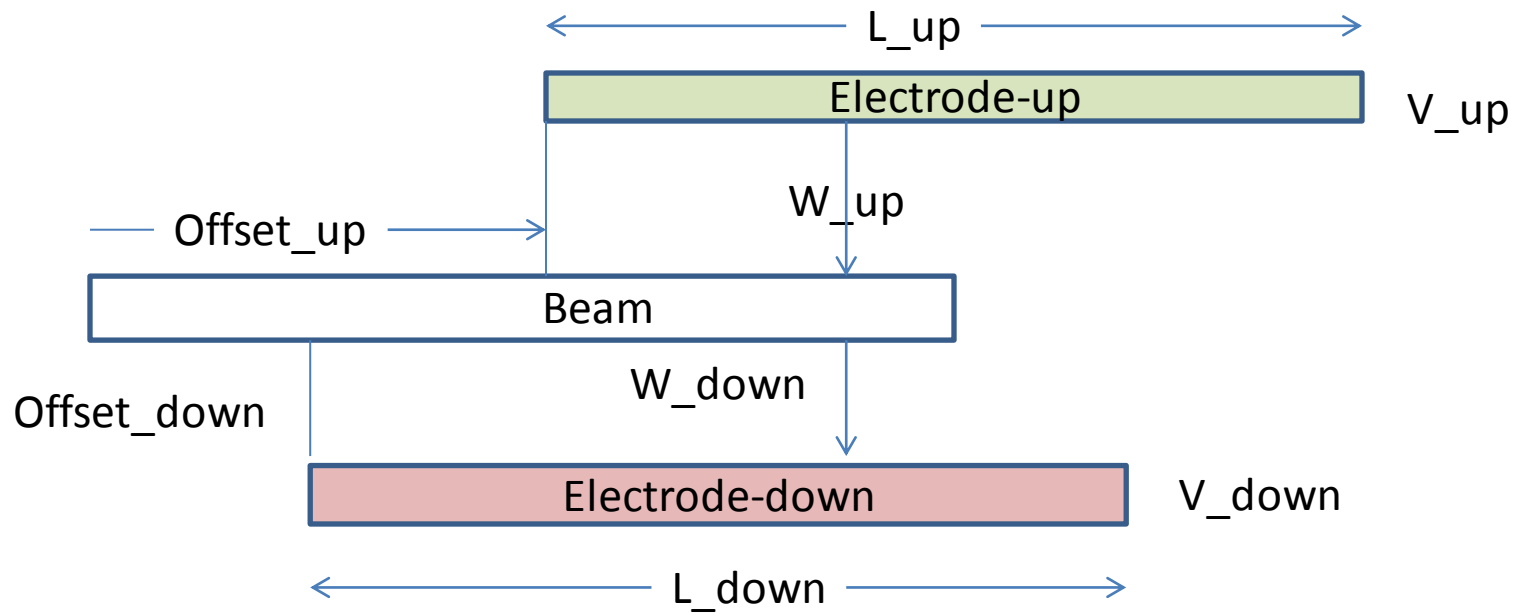
This is solved by Finite Element Method by fembeam.m and deformations are found



The Beam deforms and the force changes. The deformation problem is solved again and the iterations are repeated till steady state or Pull-in



PULL-IN

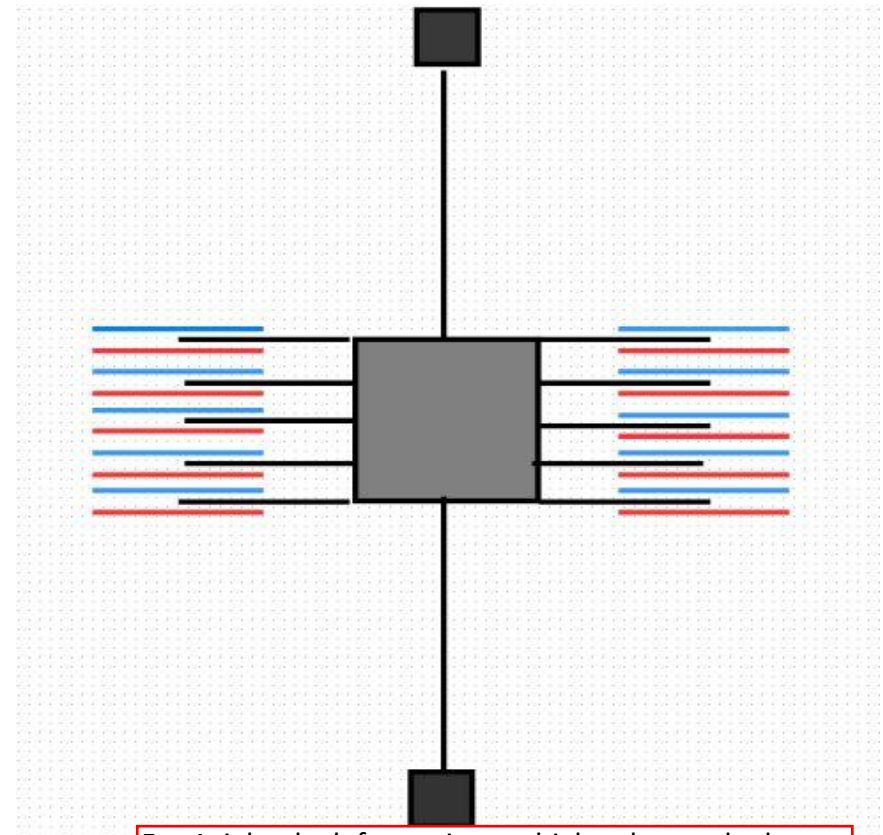
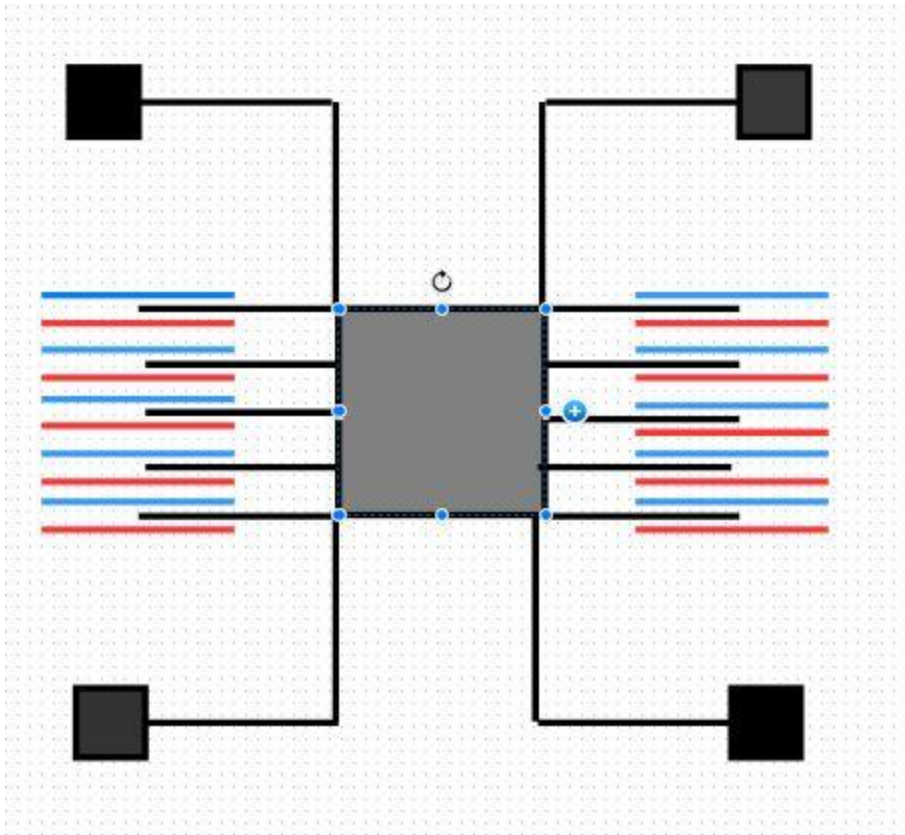


elem.dat

Sr No	Left node	Right Node	Width	Depth	Y	Wup
Lup	offset	Vup	Wdown	Ldown	offset	Vdown

If there is no electrode, fill the row with zeros

Examples for Demo



For Axial only deformation, at high voltages the beam structure rotates and falsely goes to pullin, because of some quantization error, which causes imbalance in one direction(up/down) and rotation
This will anyway happen in real system, exact balance of up/down force is rare.

- Beamsplitter.m: This function splits the beam to n parts, and makes node.dat and elem.dat
-- Extracts Gap-up and Gap-down
- Plotgap.m : This function plots the electrodes
- Pullin_gap : This variable is flag indicating which gap is in pull-in. Once this flag is set, the deformation values to be considered garbage..