MEMS cantilever beam deflection and restoration using electrostatic force.

The cantilever under consideration is shown in FIGURE 1.0 below.

If an electric field is applied between the cantilever and the baseplate, an electrostatic force is created. This force will bend the cantilever towards the baseplate. As the field is increased, the deflection will increase. When the deflection reaches approximately 2/3 of the total deflection, the process will speed up and the cantilever will touch the baseplate. The voltage at which this happens is the pull-in voltage.

The electrostatic force generated is given by:

\[ F = \frac{1}{2} eAV^2 \frac{1}{g^2} \]  

Here,

- \( e \) = permittivity of the medium between the plates
- \( g \) = distance between the plates
$V =$ applied voltage between the plates
$A =$ effective area of the plate

The restoring force that moves the cantilever back to its original position upon removal of the electrostatic force is the spring force of the cantilever. *(Note that these considerations are only valid within the elastic limits of the cantilever.)*

The restoring force is given by:

$$F_{\text{res}} = K \times \text{deflection}.$$ 

where $K$, the spring constant is given by:

$$K = \frac{E \times w \times t^3}{4 \times L^3} \text{ (N/m)} \quad (2)$$

Here,

$E =$ Young’s modulus of the cantilever material ( Gpa)
$w =$ width of the cantilever ( meter)
$t =$ thickness of the cantilever ( meter)
$L =$ length of the cantilever ( meter)

The pull-in voltage is given by:

$$V_{\text{pi}} = \sqrt{\frac{8Kg^3}{27eA}} \quad (3)$$