EE 247B / ME 218 Discussion 9

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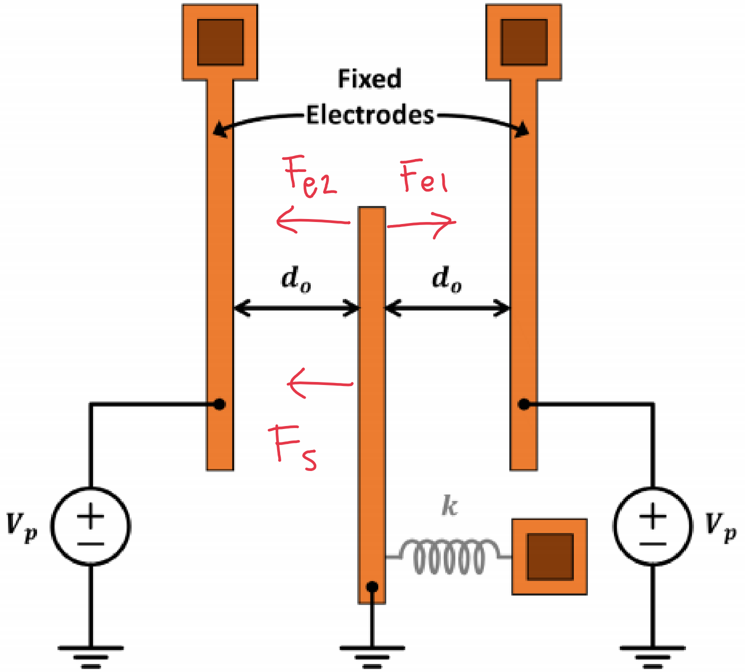
HW5, Problem 1



$(-) \leftarrow | \rightarrow (+)$ F

x

$$F_{e1} = \frac{1}{2} V_p^2 \frac{\partial}{\partial x}\left(\frac{\varepsilon A}{d_o - x}\right) \approx \frac{1}{2} V_p^2 \frac{\varepsilon A}{(d_o - x)^2}$$

$x\uparrow \Rightarrow F_{e1}\uparrow \left(\frac{\partial C_1}{\partial x} > 0\right)$

$$F_{e2} = \frac{1}{2} V_p^2 \frac{\partial}{\partial x}\left(\frac{\varepsilon A}{d_o + x}\right) \approx -\frac{1}{2} V_p^2 \frac{\varepsilon A}{(d_o + x)^2}$$

from negative $\partial C / \partial x$

$x\uparrow \Rightarrow |F_{e2}|\downarrow \left(\frac{\partial C_2}{\partial x} < 0\right)$

$$F_s = -kx$$

$$F_{net} = F_{e1} + F_{e2} + F_s = \frac{1}{2} V_p^2 \varepsilon A \left[\frac{1}{(d_o - x)^2} - \frac{1}{(d_o + x)^2}\right] - kx$$

$\frac{dF_{net}}{dx} < 0 \rightarrow$ no pull-in for some displacement dx

$$\frac{dF_{net}}{dx} = f(V_{PI}, x_{PI}) \qquad x_{PI} = 0$$

HW5, Problem 2

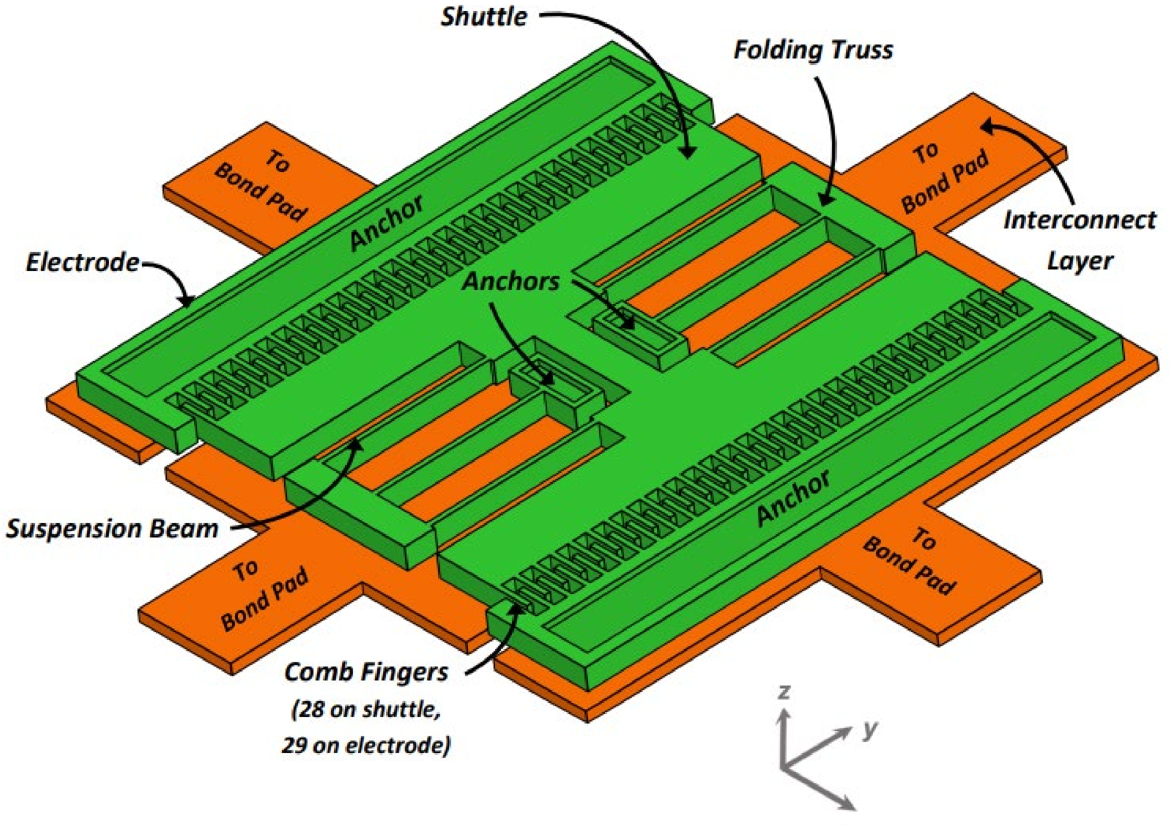


Figure PS5.2

HW5, Problem 2

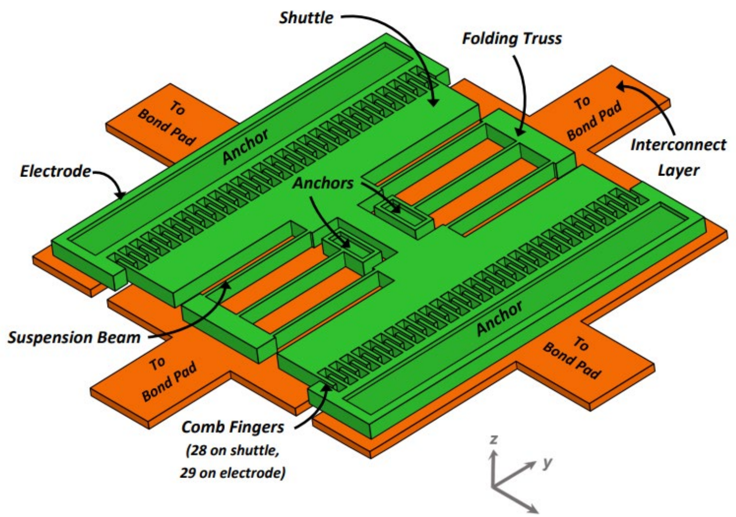
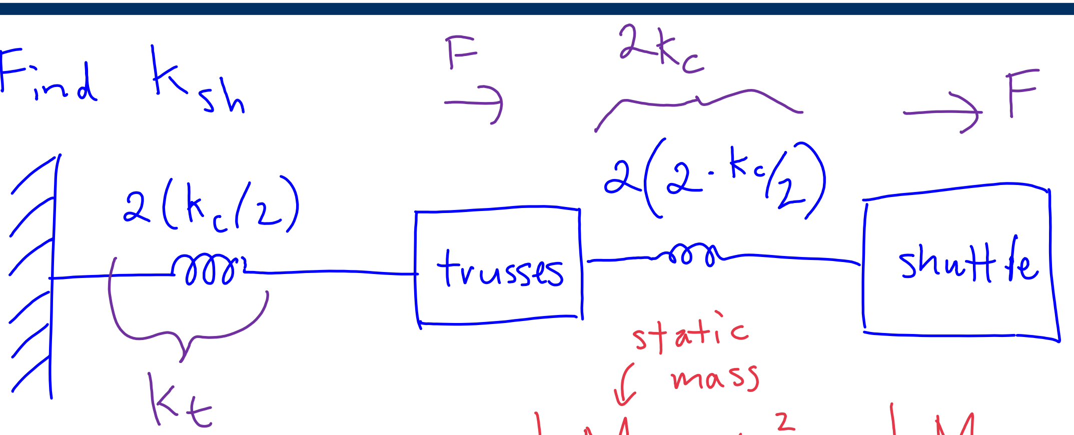


Figure PS5.2

① Find k_{sh}



$$f_0 = \sqrt{\frac{k_{sh}}{m_{sh}}}\,\frac{1}{2\pi}$$

② $m_{sh} \rightarrow KE_{tot} = \frac{1}{2}M_{sh}v_{sh}^2 + \frac{1}{2}M_{t,total}v_t^2 + \frac{1}{2}\int v_b^2\, dM_b$

dynamic mass

static mass

Truss:

$$F = k_t x_t = 2k_c(\underbrace{x_{sh}}_{x_0} - x_t)$$

$$x_t = \alpha x_0, \quad \alpha < 1$$

$$KE_t = \frac{1}{2}(2M_t)(\omega_0 x_t)^2$$

Shuttle:

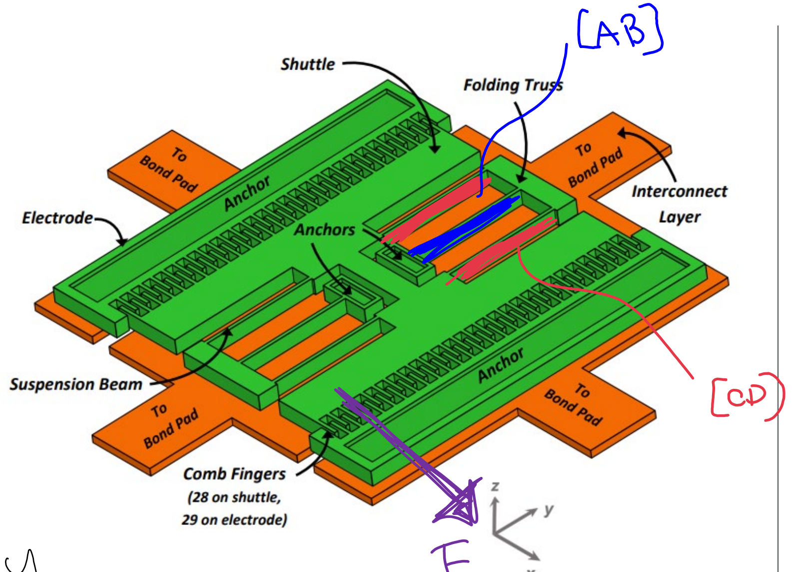
x_0 : max displacement

$v_{sh} = x_0 \cdot \omega_0$: max velocity

$$KE_{sh} = \frac{1}{2}M_{sh}\omega_0^2 x_0^2$$

BSAC

HW5, Problem 2



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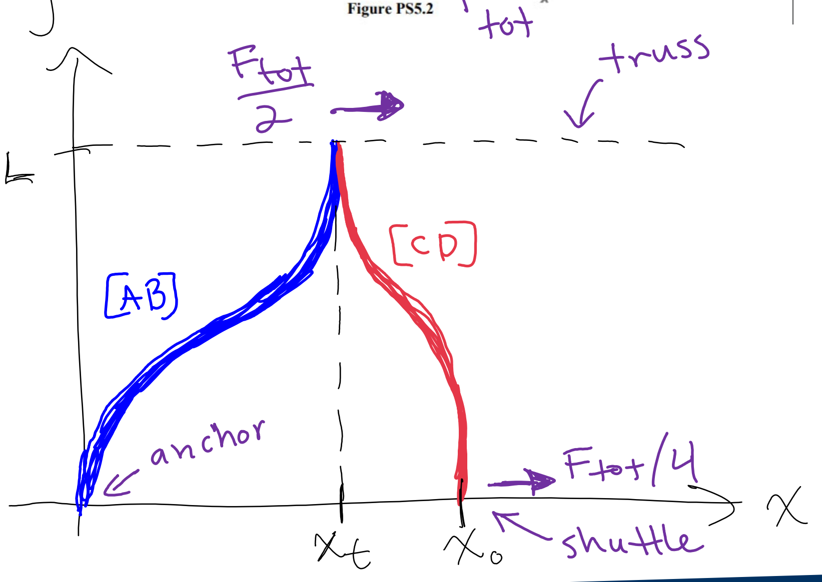

Beams:

[AB] $\frac{\partial^2 x}{\partial y^2} = x''(y) = \frac{-M(y)}{EI} = -\frac{1}{EI}\left(\frac{F_{tot}}{2}\left(\frac{L}{2}-y\right)\right)$

$\hookrightarrow x'(y) \rightarrow x(y)$

B.C.'s

$x(0) = x'(0) = 0$

$x'(L) = 0$

$x(L) = x_t = \alpha x_0$

Find $x(y, L, x_0)$

[CD] $x''(y) = \frac{F_{tot}}{4EI}\left(\frac{L}{2}-y\right)$

B.C.'s

$x'(0) = x'(L) = 0$

$x(0) = x_0$

$x(L) = x_t = \alpha x_0$

$dM_{[AB]} = \underbrace{\rho h W}_{M_{[AB]}/L} \cdot dy$

$KE_{[AB]} = \frac{1}{2}\int_0^L v^2_{[AB]}(y)\, dM_{[AB]}$

$= \frac{\omega_0^2 M_{[AB]}}{2L}\int_0^L x^2_{[AB]}(y)\, dy$