

Last time

\[ t \] \[ \text{--------} \] \[ \rightarrow \]

\[ \frac{1}{I(x)} = \frac{M(x)}{EI} \]

\( \Rightarrow \text{external loading} \)

\[ E(x) = \frac{2}{P(x)} = \frac{2M(x)}{EI} \text{ for simple loads} \]

\[ E_{\text{max}} = \frac{a F L}{2 EI} \]

\[ K = \frac{3EI}{L^3} \text{ (linear beam theory)} \]

\[ E_{\text{max}} = \frac{a (x L y(x)L)}{EI} \]

\[ y_{\text{max}} \approx (1\%) \frac{2}{3} \frac{L}{a} \]

How far can you bend a spring?

- \( E_{\text{max}} \) is a function of material and local stress concentrations (nonlinear effect)

- Sharp corner - bad

- Rounded good

- "Fillet"

- \( E_{\text{max}} = 1\% \) - effects of lithography & etch? rounding? defects?

H\(_2\) anneal
**Torsion**

\[ \tau = K \theta \]

\[ K = \frac{J G}{L} \]

\[ J = \frac{1}{2} \pi r^4 \]

\[ \sigma = \frac{F_x}{\alpha b} \]

\[ K_x = \frac{E a b}{L} \]

\[ \frac{F}{E} \]

**Axial spring constant**

\[ \frac{AL}{L} = \sigma = \frac{F}{E} \]

\[ \varepsilon_y = \nu \varepsilon_x \]

**Buckling - axial loading causes lateral deflection**

\[ F = \frac{\pi^2 E I}{(KL)^2} \]
Suspended Decay
- Specify stiffness in one or none axes
- "Large" stiffness in other axes
- No cross-axis response (ex. specific cross-axis)
- Long range, or non-linear effects

Common flexural suspension
- Assume rigid, \( (\frac{d^3}{a}) \) stiffer
- Finite elements at corners to get exact, but what geometry?
- Process variation?
- Very stiff \( K_\Omega, K_x \)

What is \( K_y \)? how does it compare to
\[ K_y = \frac{E a^3}{4 L^3} \]

Composite beams
beam 2: \( F_{x2} = F_x \)
\[ F_{y2} = F_y \]
\[ M_2 = M_0 \]

beam 1: \( F_{y1} = F_y \)
\[ F_{x1} = F_x \]
\[ M_1 = M_0 + F_x L_2 \]
SUGAR

\[ K_y = 2K_1 \] guided

\[ K_l = \frac{1}{2} K_0 = 4K_L \]
\[ K_0 = \frac{E a^{33}}{4(\frac{1}{2})} = 8K_L \]
\[ K_y = 2K_1 = 8K_L \]