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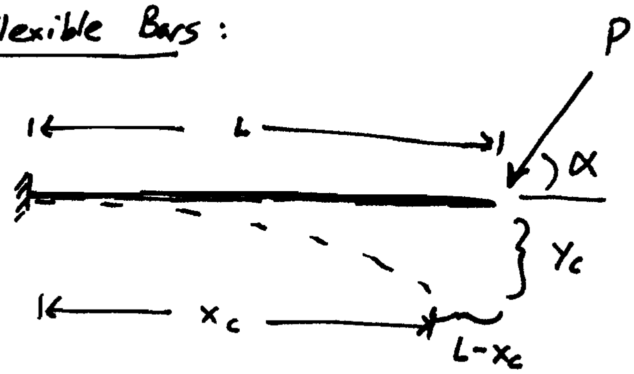
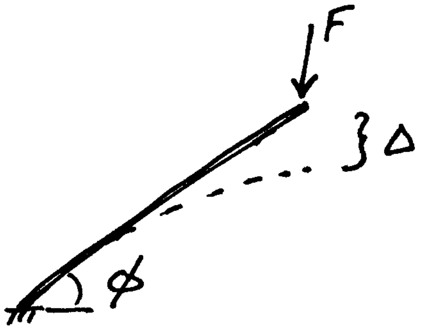
Derivation of Equation (1) in
Autumn et al. J. Experimental Biology v. 209, 3558 (2006)
using results from Frisch-Fay *Flexible Bars* (1961)

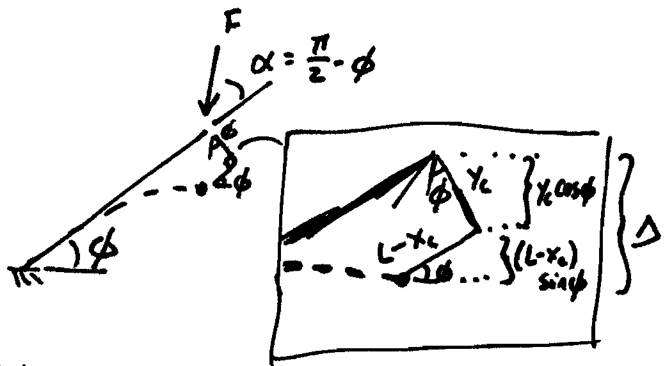
- In *Flexible Bars*:



- In Autumn et al.:



$\Delta = \Delta(F)$ is derived from the relationships $y_c = y_c(P,\alpha)$ and $x_c = x_c(P,\alpha)$ using a *coordinate transformation*



- Derivation:

$$\Delta = (L - x_c)\sin\phi + y_c\cos\phi \qquad (1)$$
$$P = F \qquad (2)$$
$$\alpha = \frac{\pi}{2} - \phi \qquad (3)$$

from Flexible Bars,

$$x_c = K^{-1}(\cos\alpha)G + 2pk^{-1}\sin\alpha\cos m \qquad (4)$$
$$y_c = -k^{-1}(\sin\alpha)G + 2pk^{-1}\cos\alpha\cos m \qquad (5)$$

where $G = F - K + 2E - 2E'$

Next, substitute α w/ $\frac{\pi}{2} - \phi$ and <u>note that</u> $\boxed{\cos\alpha = \cos(\frac{\pi}{2} - \phi) = \sin\phi}$ and $\sin\alpha = \sin(\frac{\pi}{2} - \phi) = \cos\phi$. Hence,

$$\Delta = L\sin\phi - \{k^{-1}(\sin\phi)G + 2pk^{-1}\cos\phi\cos m\}\sin\phi$$
$$+ \{-k^{-1}(\cos\phi)G + 2pk^{-1}\sin\phi\cos m\}\cos\phi$$

Derivation cont...

From the identity $\sin^2\phi + \cos^2\phi = 1$ it follows that

$$\Delta = L\sin\phi - k^{-1}G$$

$$\therefore \boxed{\Delta = L\sin\phi - [F - K + 2E - 2E']/k}$$

note that the $2pk^{-1}\cos\phi\cos m\sin\phi$ and $2pk^{-1}\sin\phi\cos m\cos\phi$ terms cancel eachother out.