## Stiffness Transformation

$$\begin{split} \mathbf{K} &\equiv \left(\frac{\partial \tau_i}{\partial q_j}\right) = \left(\frac{\partial (\mathbf{J}^T \mathbf{F})_i}{\partial q_j}\right) \\ &= \left(\sum_k \frac{\partial (\mathbf{J}^T)_{ik}}{\partial q_j} F_k\right) + \mathbf{J}^T \left(\frac{\partial F_i}{\partial q_j}\right) \\ &= \left(\sum_k \frac{\partial (\mathbf{J}^T)_{ik}}{\partial q_j} F_k\right) + \mathbf{J}^T \sum_k \left(\frac{\partial F_i}{\partial x_k}\right) \left(\frac{\partial x_k}{\partial q_j}\right) \end{split}$$

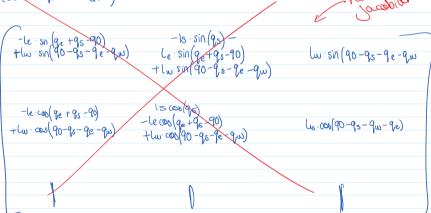
$$\mathbf{K} = \frac{d\mathbf{J}^T}{d\mathbf{q}}\mathbf{F} + \mathbf{J}^T\mathbf{K}_x\mathbf{J}$$

similarly

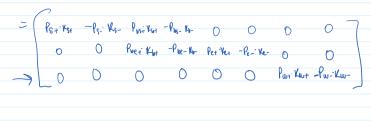
$$\mathbf{K} = \frac{d\mathbf{J}_{\mu}^{T}}{\mathbf{q}} \boldsymbol{\mu} + \mathbf{J}_{\mu}^{T} \mathbf{K}_{\mu}^{T} \mathbf{J}_{\mu} \qquad \qquad \text{this jacobian is}$$
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