11.14 Optional: Neuromuscular biomechanics: Muscle tensions for curling

- Referring to Section 17.6, verify the scalar equation corresponding to a static pose with $q_B = 90^\circ$.

Result:

\[
0.04896 T_{\text{Biceps}} + 0.02320 T_{\text{Brachialis}} = 37.854
\]

- Calculate the biceps and brachialis moment-arms when $q_B = 90^\circ$.

Result:

Biceps = 4.896 cm Brachialis = cm

- Optional: Verify the results for the criteria (resolving indeterminate forces): biceps only, brachialis only, equal tension, equal stress, and moment-arm ratio.

- Optional: Verify the results that minimize muscle tension, muscle stress, and metabolic energy, and optionally muscle activation.

- Optional: Consider the criteria that minimizes the sum-square of muscle tensions. Plot the static solution for the biceps tension for $0^\circ \leq q_B \leq 165^\circ$.

Repeat for the dynamic solution when $q_B(t)$ is the following transition function\(^a\) from $q_B(0) = 0^\circ$ to $q_B(t_f) = 165^\circ$.

\[
q_B(t) = q_B(0) + \frac{q_B(t_f)-q_B(0)}{t_f} t + \frac{q_B(t_f)-q_B(0)}{2 \pi} \sin\left(\frac{2\pi t}{t_f}\right)
\]

\(^a\)The 1\(^{st}\) and 2\(^{nd}\) time-derivative of this transition function are zero at both $t = 0$ and $t = t_f$. The function attains its minimum and maximum values at end-points. Large $t_f$ (e.g., $t_f = 20$ min) produces a quasi-static solution.

The results show the biceps dominate curling for physiologically feasible angles ($q_B \leq 150^\circ$). The results also show negative brachialis tension which violates the condition that muscles can pull not push (part of these results are unrealistic). Various ways to modify this analysis include:

- Adding triceps muscles
- Optimizing with inequality constraints
- Trying a different cost function