Problem 3 (Use Simscape Multibody)

(a) See provided Simscape solution file. After running the model, you can generate the plots by executing this Matlab line: `plot(q1); hold on; plot(w1);`.

(b) See provided Simscape solution file. The formulas for the inertia properties can be found in the *Inertia* properties of the Solids. Note that, because *L*, *W*, and *H* are defined in centimeters but the inertia properties in kilograms and meters, *L*, *W*, and *H* have to be scaled to meters in all expressions.

(c) See provided Simscape solution file.

☠ The caveat lies in the chaotic behavior of a double pendulum. Tiny changes in parameters or initial conditions can create large effects over time. To give an example: In the solution file for Problem 3b, we conducted the scaling to meters individually for each *L*, *W*, and *H* everywhere where these variables appeared in the Inertia properties. Instead, for each formula, one may also factor out all scaling coefficients and scale the entire formula by a single coefficient. For example, the expression for *Mass* would then become *L*W*H*pho/10^6*. Due to sensitivity of the system, the numerical difference between the two approaches is enough to lead to a different behavior for longer simulation times. The deviations are not visible during a 5 second simulation but become more apparent after 10 seconds, as shown in Figure 1 (both lines in the figure show the angle between the links; the solid line corresponds to individual scaling of each linear dimension and the dashed line to scaling of each inertia property with a single coefficient).

Figure 1