**Simulation Lab #4:**

**Dynamic Modeling and Simulation   
of Muscle-Tendon Actuators**

Modeling and Simulation of Human Movement

BME 599

Laboratory Developers: Jeff Reinbolt, Hoa Hoang, B.J. Fregly, Kate Saul,   
Darryl Thelen, Silvia Blemker, Clay Anderson, Scott Delp

# VI. Muscle Tug of War Model

How many degrees of freedom are in this model? What are they?

What are the values of the four primary muscle parameters () for each muscle?

What do the excitations for the muscles look like? Draw them.

Look through the files that were given to you. Where is the Actuation analysis called, and where are the results saved?

Plot box position vs. time, muscle activations vs. time, and muscle force vs. time.

# VII. Exploration Phase

List all of the changes you had to make to change the two-muscle simulation into a one-muscle simulation, and which files were affected.

What is the syntax needed to lock the block in the .osim file?

Isometric simulations: Overlay curves of the muscle force-time histories for each tendon-to-fiber length ratio. Describe any differences that you see between the curves in terms of the rate of force development and steady state force achieved. Using what you know about muscle activation dynamics and muscle-tendon mechanics, explain why the muscle force responses differ the way they do with changes in tendon-to-fiber length ratio.

Isokinetic simulations: Overlay curves of the tendon force-position histories for each tendon-to-fiber length ratio. Describe any differences that you see between the shapes of the curves. Using what you know about muscle-tendon mechanics, explain why the muscle force responses differ the way they do with changes in tendon-to-fiber length ratio.

# VIII. Design Phase

You are individually responsible for devising and implementing a process for designing your muscle-tendon actuator. Document the process and results clearly in a brief report. The report, excluding figures and tables, should not be more than 2 pages. Include the following sections:

* Introduction
  + Objectives of your design.
* Methods
  + Outline of the steps used in your design process.
* Results
  + Include a combination of mathematical analysis, parameter sensitivity studies, and results of prototype muscle simulations.
  + Description of the final muscle design, including a demonstration that each criterion is met.
* Discussion
  + Justification of your final design.
  + Evaluation of the strengths and potential weaknesses of your design, e.g. under what conditions do you expect your muscle to perform well?
* References if used