MCEN 4228/5228
Modeling of Human Movement
(K): Knowledge Problem, (C): Challenge Problem, (EX): Extra Credit
HW04

1. (K) The file *legextension.m* performs a simulation of a leg extension exercise with two legs. It assumes a quasi-static situation and models the force-length curve of muscle (and not force-velocity).

1a. Examine the m-file, sketch the mathematical functions contained therein, and briefly explain what they represent.

1b. Plot the maximum available moment that can be exerted by the two legs for three cases: moment arm as given, and moment arm ± 10%.

1c. Suppose the extension moment was not quasi-static, that is, the velocity is not approximately zero. What would you expect would happen to the maximum moment curve?

2. (K) Run the MATLAB program *runkick.m*, which performs a kick simulation similar to the leg extension exercise, but this time including the force-velocity relationship.

2a. Plot the normalized force-velocity curve used in the simulation, for the shape parameter *af* given and for several values ranging from 0.1 to 0.4.

2b. Plot the normalized power that can be produced as a function of shortening velocity (all in normalized units), for a range of shape parameters. Briefly describe the effect of the shape parameter on the force-velocity curve, and the power-velocity curve.

2c. Now run the kick simulation for various shape parameter values, and comment on how the parameter affects your results.

3. (C) Muscles Hans and Franz have both entered the prestigious Muscle Olympics (leaving their pesky tendons at home). They will each compete in three events in an attempt to bring home the coveted Golden Sarcomere. Being the poor student that you are, you're hoping to make a little extra cash by placing some bets on the competition. The Olympic program with the competitor's vital stats has just arrived in the mail and your bookie is on the phone – what bets do you want to place?
For each event, predict whether Hans or Franz will win. Defend your choice using muscle mechanics principles and equations we've discussed in class. (You get credit for your reasons, not for just correctly guessing the winner). If there is a muscle property that you think is important that isn't listed, assume that it is the same for both Hans and Franz. *Assume both muscles have linear force-length properties and moment arms that are constant with joint angle*. For all events, the muscles are loaded into a revolute joint with the given moment arm.

	Hans	Franz
Fmax (N)	150	150
Optimal fiber length (cm)	6	6
Moment arm (cm)	2	1.75

3a. "Clean and Jerk": The joint moves through a range of motion at a constant angular velocity of 100°/sec. The winning muscle is that which produces the most force at the instant that it reaches optimal fiber length.

3b. "60° Torque-off": Each joint is fixed at 60°. The winning muscle is that which produces the largest torque during an isometric contraction. Assume that each muscle is at optimal fiber length when the joint is at 60°.

3c. "110° Torque-off": Each joint is fixed at 110°. The winning muscle is that which produces the largest torque during an isometric contraction. Assume again that each muscle is at optimal fiber length when the joint is at 60°.

Hans and Franz were both not satisfied with their performance in the Torque-off competitions – they each thought they should be able to win both the 60° and 110° categories. They convince the Olympic officials to let them have a rematch. Over the weekend, both muscles worked hard to try to improve their odds. Franz went to the local Gold's Gym and bulked up. Hans went to the local yoga studio and stayed in downward-facing dog all weekend. After this intense conditioning, their vital stats had changed.

	Hans	Franz
Fmax (N)	150	200
Optimal Fiber length (cm)	9	6
Moment arm (cm)	2	1.75

Based on their new stats, predict the winners to the torque-off rematches:

3d. "60° Torque-off" re-match: Each joint is fixed at 60°. The winning muscle is that which produces the largest torque during an isometric contraction. Assume that each muscle is at optimal fiber length when the joint is at 60°.

3e. "110° Torque-off" re-match: Each joint is fixed at 110°. The winning muscle is that which produces the largest torque during an isometric contraction. Assume again that each muscle is at optimal fiber length when the joint is at 60°.

3f. Using what you learned in this problem, comment on why we may have redundant muscles in our bodies.

4. (K) Read the assigned journal article for the week. Based on class lectures, identify and discuss a limitation to their approach.

To Submit Online:
1. ONE homework document as a .pdf: handwritten, scanned or a combination.