ANSWER SHEET
OpenSim Tutorial #1
Introduction to Musculoskeletal Modeling

Laboratory Developers: Scott Delp, Allison Arnold, Samuel Hamner
Neuromuscular Biomechanics Laboratory
Stanford University

1. **Degrees of Freedom**
   - **a.** *How many degrees of freedom does the model have?*

   - **b.** *Which motions have been simplified? Which motions have not been modeled at all?*

   - **c.** *How many muscles are in the model? Is this greater than the number of degrees of freedom? What is the minimum number of muscles required to fully actuate the model?*
     Hint: Full actuation of the knee, for example, means both knee flexion and knee extension.

2. **Muscle Paths**
   - **a.** *Name two other muscles in the model that are represented with multiple lines of action. Why do you think these muscles are represented in this way?*
     Hint: Other muscles with multiple lines of action use the same naming convention as the gluteus medius.

   - **b.** *Which knee extensor muscles have wrapping points? At what knee angle do they occur?*

3. Modeling Limitations

Do you see any problems with GMAX3? In what ways are point-to-point representations of muscle paths a simplification of musculoskeletal geometry?

4. Muscle Fiber Length vs. Joint Angle

a. Study the plot of muscle fiber length vs. knee angle. *Do you think these curves would look different if, for example, the right hip was flexed?*

b. Compare the two sets of curves you have just plotted. *How have the curves changed? Can you explain your findings? How can bi-articular muscles complicate analysis?*

5. Muscle Moment Arm vs. Joint Angle

Study the plot of knee extension moment arm vs. knee angle for rectus femoris and vastus intermedius. *At what knee angles do the moment arms peak? What are the peak moment arms?*

At what knee angle does the discontinuity occur? What do you think causes this?

Hint: Look at Question 2.b

6. Range of Motion

What differences do you observe?

Identify the intervals at which heel strike, stance, toe off, and swing phase occur for a "normal" gait cycle?

What is the "normal" range of knee flexion during stance phase? How does this knee flexion curve for crouch gait compare to the normal gait data?

7. Hamstrings Length

Study the curves. *Based on the plot, what recommendation would you give the surgeon? Can you think of any limitations of your analysis?*

8. Additional Crouch Gait Files (optional)

Would your recommendations to the surgeon be any different for these patients?