

MATLAB Assignments

Spring 2012

MATLAB Assignment #1

due Thursday 5/10/12, by 9:10 a.m.

***NO LATE ASSIGNMENTS WILL BE ACCEPTED!***

MATLAB Assignment #1 focuses on the forward and inverse pose kinematics of the human arm. The text is Section 3.1.2 of Dr. Bob's biomechanics notes. Use the simplified planar 3-dof human arm model where  $L_1$  is the upper arm length,  $L_2$  is the forearm length,  $L_3$  is the hand length,  $\theta_1$  is the absolute shoulder pitch angle,  $\theta_2$  is the relative elbow pitch angle, and  $\theta_3$  is the relative wrist pitch angle.

Your assignment is to replicate the plots given in the notes. Choose either the adult female or adult male model, no need to do both – clearly state your choice in your memo. For both cases below, animate the simulated human arm to the screen (the FPK m-file in the notes shows you how to do this).

1. Perform **forward pose kinematics** simulation in MATLAB according to the same inputs as in the notes. Artificially map the entire motion to a time range from 0 to 3 sec. The MATLAB program is given for you in the notes – feel free to adapt this for your m-file. Plot:

- Input angles ( $\theta_1, \theta_2, \theta_3$ ) vs. time
- FPK results ( $x, y, \phi$ ) vs. time
- FPK results ( $y$  vs.  $x$ ; square axes with equal  $X, Y$ , ranges)
- Simulated muscle lengths (biceps and triceps) vs. time
- Simulated muscle angles (biceps and triceps) vs. time
- Initial and final arm poses ( $y$  vs.  $x$ ; square axes with equal  $X, Y$ , ranges).

2. Perform **inverse pose kinematics** simulation in MATLAB according to the same inputs as in the notes. Use exactly  $N = 48$  steps, artificially mapped to a time range from 0 to 2 sec. The MATLAB program is not given for you in the notes, but you can modify the above m-file. Plot:

- Input Cartesian pose ( $x, y, \phi$ ) vs. time
- IPK results ( $\theta_1, \theta_2, \theta_3$ ) vs. time
- Simulated muscle lengths (biceps and triceps) vs. time
- Simulated muscle angles (biceps and triceps) vs. time
- Initial and final arm poses ( $y$  vs.  $x$ ; square axes with equal  $X, Y$ , ranges).

The first page of your MATLAB Assignment #1 report must be a one-page memo. You are expected to work with others on the concepts and MATLAB strategies – however, all computer work and written work must be strictly individual. Start early and ask questions at any time – the answer key for this assignment is in the notes.

## MATLAB Assignment #2

due Thursday 5/17/12, by 9:10 a.m.

### ***NO LATE ASSIGNMENTS WILL BE ACCEPTED!***

MATLAB Assignment #2 focuses on the pseudostatics simulation of the human elbow joint. The text is Section 3.2.2 of Dr. Bob's biomechanics notes. Use the further simplified planar 1-dof human arm model where  $L_1$  is the upper arm length,  $L_2$  is the forearm length,  $L_3$  is the hand length,  $\theta_1 = 0$  is the absolute shoulder pitch angle,  $\theta_2$  is the relative elbow pitch angle, and  $\theta_3 = 0$  is the relative wrist pitch angle. A constant end load (vertical, down) of  $W_L = 22.24$  N (5 lb) is given at the fingertips.

Your assignment is to replicate the plots given in the notes. Choose either the adult female or adult male model, whichever you chose in MATLAB Assignment #1. For the pseudostatics simulation, animate the simulated human arm to the screen.

1. Perform **biceps pseudostatics** simulation in MATLAB according to the same inputs as in the notes, for  $t_T = 0$ . Plot:

- Cycloidal input angle  $\theta_2$  vs. time
- Biceps pseudostatics results ( $t_B$  vs. time)
- Biceps pseudostatics results ( $F_{Ex}$  and  $F_{Ey}$  vs. time)
- Simulated muscle lengths (biceps and triceps) vs. time
- Simulated muscle angles (biceps and triceps) vs. time
- Initial and final arm poses ( $y$  vs.  $x$ ; square axes with equal  $X, Y$ , ranges).

Discuss your results. As the notes point out, this simulation is not acceptable since there are negative biceps tensions for a portion of the motion; therefore:

2. Perform **triceps pseudostatics** simulation in MATLAB according to the same inputs as in the notes, for  $t_B = 0$ . Plot:

- Triceps pseudostatics results ( $t_T$  vs. time)
- Triceps pseudostatics results ( $F_{Ex}$  and  $F_{Ey}$  vs. time)

The other plots will be identical to those from 1 above. Discuss your results. As the notes point out, this simulation is still not acceptable since there are negative triceps tensions for a portion of the motion; therefore:

3. Perform **acceptable biceps/triceps pseudostatics** simulation in MATLAB according to the same inputs as in the notes. Plot:

- Biceps/triceps pseudostatics results ( $t_B$  and  $t_T$  vs. time)
- Biceps/triceps pseudostatics results ( $F_{Ex}$  and  $F_{Ey}$  vs. time)

Again, the other plots will be identical to those from 1 above. Discuss your results.

The first page of your MATLAB Assignment #2 report must be a one-page memo. You are expected to work with others on the concepts and MATLAB strategies – however, all computer work and written work must be strictly individual. Start early and ask questions at any time – the answer key for this assignment is in the notes.

## MATLAB Assignment #3

due Thursday 5/24/12, by 9:10 a.m.

### ***NO LATE ASSIGNMENTS WILL BE ACCEPTED!***

MATLAB Assignment #3 focuses on the dynamics simulation of the human elbow joint. The text is Section 3.3.2 of Dr. Bob's biomechanics notes. Use the same simplified planar 1-dof human arm model from pseudostatics where  $L_1$  is the upper arm length,  $L_2$  is the forearm length,  $L_3$  is the hand length,  $\theta_1 = 0$  is the absolute shoulder pitch angle,  $\theta_2$  is the relative elbow pitch angle, and  $\theta_3 = 0$  is the relative wrist pitch angle.

Your assignment is to replicate the plots given in the notes. Choose either the adult female or adult male model, whichever you chose in MATLAB Assignments #1&2. For the dynamics simulation, animate the simulated human arm to the screen.

1. Perform **biceps dynamics** simulation in MATLAB according to the same inputs as in the notes (use only  $t_F = 0.5$  sec). Plot:

- Cycloidal input angle  $\theta_2$  and derivatives through jerk vs. time
- CG accelerations vs. time
- Biceps dynamics results ( $t_B$  vs. time)
- Biceps dynamics results ( $F_{Ex}$  and  $F_{Ey}$  vs. time)
- Simulated muscle lengths (biceps and triceps) vs. time
- Simulated muscle angles (biceps and triceps) vs. time
- Initial and final arm poses ( $y$  vs.  $x$ ; square axes with equal  $X, Y$ , ranges).

Discuss your results. As the notes point out, this simulation is not acceptable since there are negative biceps tensions at times; therefore:

2. Perform **triceps dynamics** simulation in MATLAB according to the same inputs as in the notes (use only  $t_F = 0.5$  sec). Plot:

- Triceps dynamics results ( $t_T$  vs. time)
- Triceps dynamics results ( $F_{Ex}$  and  $F_{Ey}$  vs. time)

The other plots will be identical to those from 1. above. Discuss your results. As the notes point out, this simulation is still not acceptable since there are negative triceps tensions for a portion of the motion; therefore:

3. Perform **acceptable biceps/triceps dynamics** simulation in MATLAB according to the same inputs as in the notes. Plot:

- Biceps/triceps dynamics results ( $t_B$  and  $t_T$  vs. time)
- Biceps/triceps dynamics results ( $F_{Ex}$  and  $F_{Ey}$  vs. time)

Again, the other plots will be identical to those from 1 above. Discuss your results.

The first page of your MATLAB Assignment #3 report must be a one-page memo. You are expected to work with others on the concepts and MATLAB strategies – however, all computer work and written work must be strictly individual. Start early and ask questions at any time – the answer key for this assignment is in the notes.