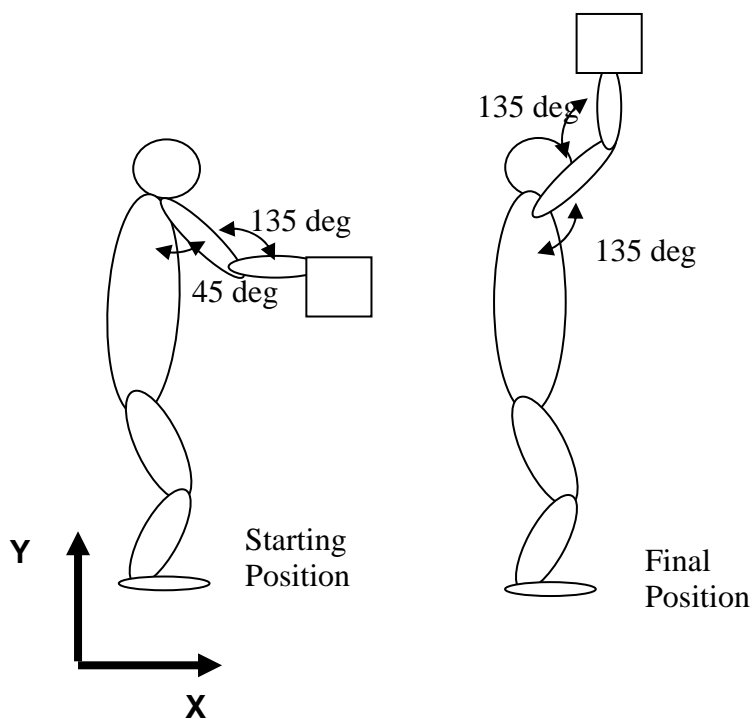


**Homework**  
**Kinematics Lecture**  
**Feb 9, 2009**

1. Write the following rotation matrices. Make sure you draw the LCS on the segments first:

- a) Forearm with respect to the GCS for the starting position
- b) Forearm with respect to the GCS for the final position
- c) Forearm with respect to the upper arm for the starting position
- d) Forearm with respect to the upper arm for the final position

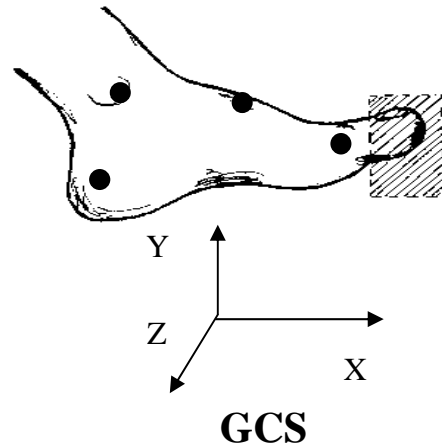


2. A rigid body, initially aligned with the GCS, is translated by 100 cm in the X direction and rotated by +180 degrees about the local z axis.

- a) If a point in the local coordinate system is  $P_L=[1, 1, 1]$ ; what is the point location in the global coordinate system after the move?
- b) The rigid body is now rotated -90 degrees about the local X axis. What is the transformation matrix ( $T_{GL}$ ) after this rotation?

3. Markers were placed on the foot as follows:

$$\text{Forefoot} = \begin{bmatrix} 1 \\ 7 \\ 5 \end{bmatrix} \quad \text{Ankle} = \begin{bmatrix} -1 \\ 8 \\ 5 \end{bmatrix} \quad \text{Heel} = \begin{bmatrix} -2 \\ 5 \\ 5 \end{bmatrix} \quad \text{Toe} = \begin{bmatrix} 5 \\ 6 \\ 5 \end{bmatrix}$$



- a) Compute an orthonormal LCS (Draw the LCS axes on the picture.)
- b) What is  $T_{G1}$ ?
- c) If the foot is rotated about the ankle +90 degrees, what is the new transformation matrix ( $T_{G2}$ )?