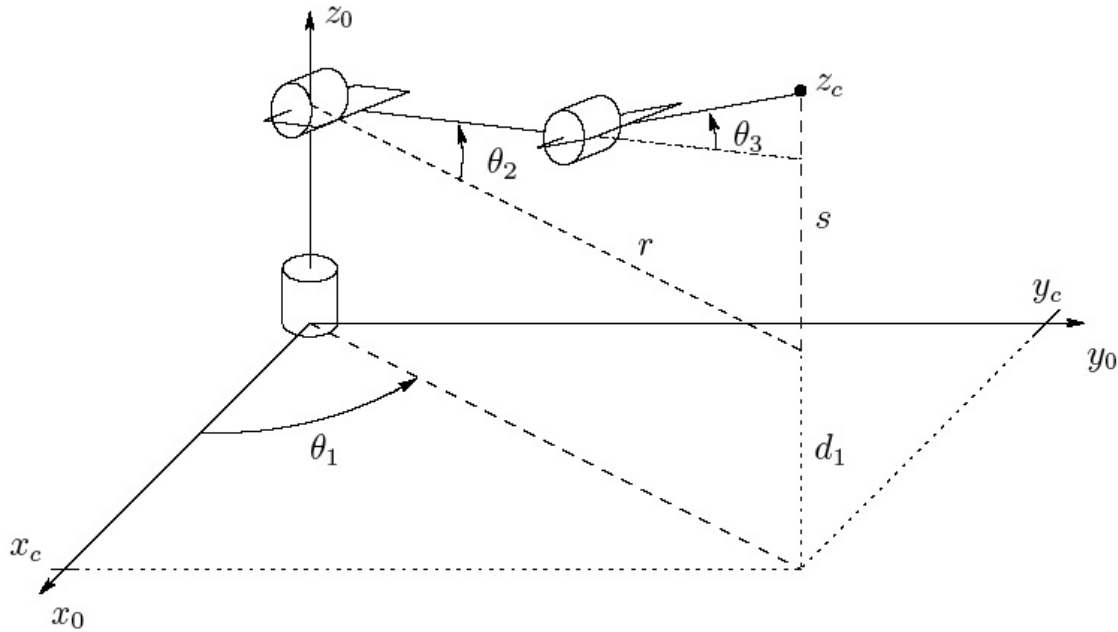


## ECE 5397/6397: Intro to Robotics HW 4, Due March 4 The manipulator Jacobian

1. Calculate the manipulator Jacobian of the anthropomorphic manipulator at the position  $z_c$ .
  - a. Write out the J matrix in terms of  $z_i$  and  $o_i$ .
  - b. Write out the J values. Calculate the cross products. You may use your previous calculations for the A and T matrices.



$$T_1^0 = \begin{bmatrix} c_1 & 0 & s_1 & 0 \\ s_1 & 0 & -c_1 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_2^0 = \begin{bmatrix} c_1 c_2 & -c_1 s_2 & s_1 & r_2 c_1 c_2 \\ c_2 s_1 & -s_1 s_2 & -c_1 & r_2 c_2 s_1 \\ s_2 & c_2 & 0 & d_1 + r_2 s_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_3^0 = \begin{bmatrix} c_1 c_{23} & -c_1 s_{23} & s_1 & c_1 (r_2 c_2 + r_3 c_{23}) \\ c_{23} s_1 & -s_1 s_{23} & -c_1 & (r_2 c_2 + r_3 c_{23}) s_1 \\ s_{23} & c_{23} & 0 & d_1 + r_2 s_2 + r_3 s_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. Calculate the manipulator Jacobian of the cylindrical robot with spherical wrist manipulator at the position  $z_6$ .
  - a. Write out the J matrix in terms of  $z_i$  and  $o_i$ .
  - b. Write out the J values. Calculate the cross products. You may use your previous calculations for the A and T matrices.

