# Robotics Assignment – Manipulator Kinematics

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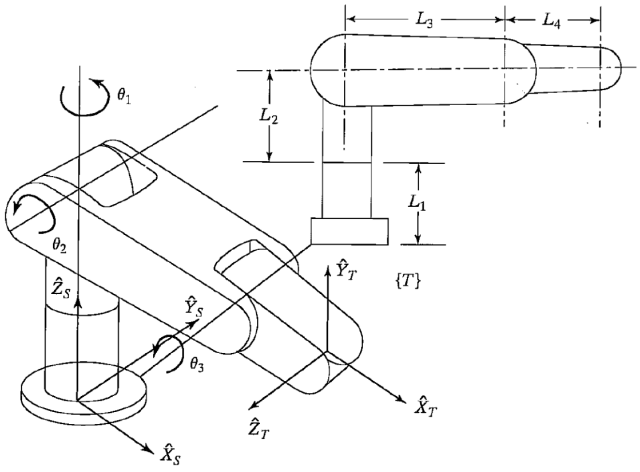
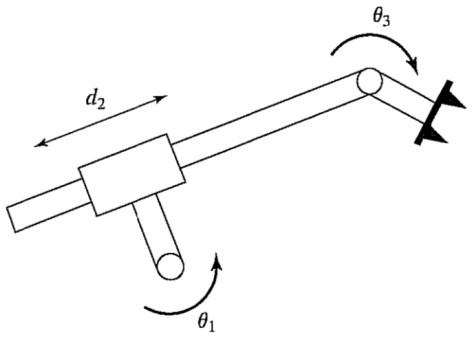
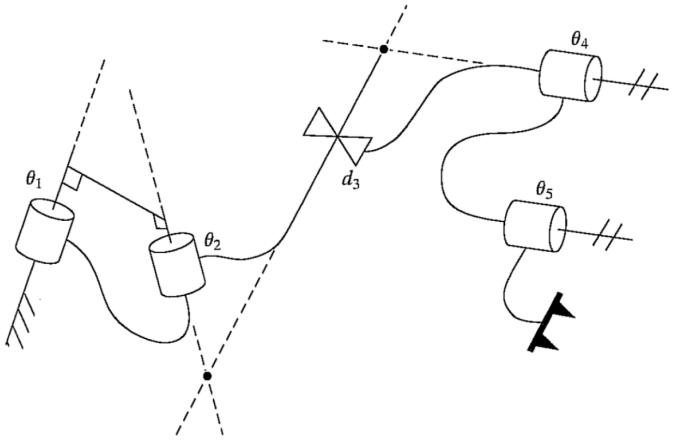
**1** The arm with three DOF shown in the figure has joints 0 and 1 perpendicular to joints 2 and 3. As pictured, all joints are at their zero location. Note that the positive sense of the joint angle is indicated. Assign link frames $\{0\}$ through $\{3\}$ for this arm, then derive the DH-parameters. Find the transformation matrices ${}^0_1T$, ${}^1_2T$, and ${}^2_3T$.



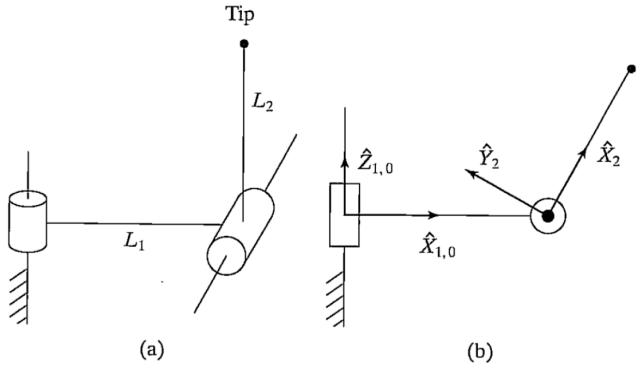

**2** Assign link frames to the RPR planar robot shown in the figure and give the DH-parameters.




**3** Show the attachment of link frames of the 5-DOF manipulator shown schematically in the figure.



**4** For the two-link manipulator shown in the figure, obtain the link transformation matrix. Find an expression for the vector ${}^0P_{tip}$ which locates the tip of the arm relative to the base frame.




**5** In the figure, the location of the tool, ${}^W_T T$, is not accurately known. Using force control, the robot feels around with the tool tip until it inserts it into the socket (or Goal) at location ${}^S_G T$. Once in this calibration configuration in which $\{G\}$ and $\{T\}$ are coincident, the position of the robot, ${}^B_W T$, is figured out by reading the joint angle sensors and computing the kinematics. Assuming ${}^B_S T$ and ${}^S_G T$ are known, give the transform equation to compute the unknown tool frame ${}^W_T T$.