

**ECE 5397/6397: Intro to Robotics**

**Class Worksheet – Lecture 5:** Forward kinematics: Denavit-Hartenberg convention and the derivation of D-H transformation matrix, assigning link frames using the DH convention.

Constraints on How many DOF?

DH1: The axis is perpendicular to the axis

DH2: The axis intersects the axis

**Step 1:** locate and label the joint axis

**Step 2:** Establish the base frame. Set the origin anywhere on the -axis. The and axes are chosen conveniently to form a right-handed frame.

**For** perform steps 3 to 5:

**Step 3:** Locate the origin where the common normal to and intersects If intersects , locate at this intersection. If and are parallel, locate in any convenient position along .

**Step 4:** Establish along the common normal between and through ,

or in the direction normal to the plane if and intersect.

**Step 5:** Establish to complete a right-handed frame

**Step 6:** Establish the end-effector frame . Assume the joint is revolute, set parallel to . Establish the origin conveniently along , preferably at the center of the gripper or at the tip of any tool that the manipulator may be carrying. Set in the direction of the gripper closure and set as . If the tool is not a simple gripper, set and conveniently to form a right-handed frame

**Step 7:** Create a table of DH parameters .

distance along from the intersection of the and axes to

distance along from to the intersection of the and axes. If joint and is prismatic, is variable.

the angle from to measured about

the angle from to measured about If joint is revolute, is variable.

**Step 8:** Form the homogenous transformation matrices by substituting the above parameters into

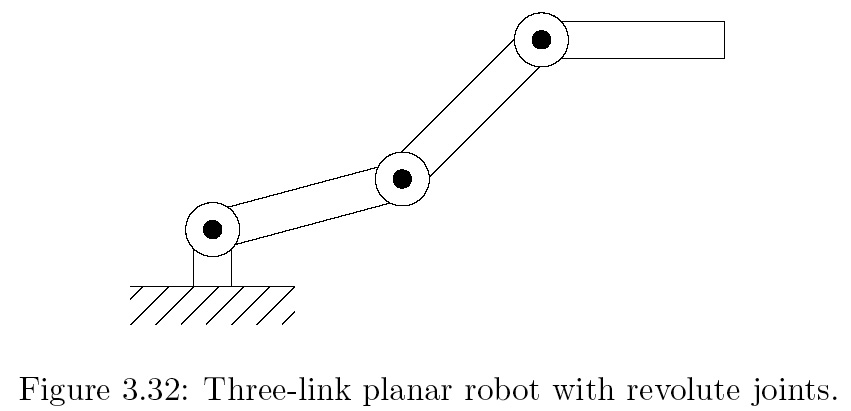
**Step 9:** Form . This then fixes the position and orientation of the tool frame expressed in base coordinates.

\* indicates variable

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**Class Worksheet – Preparation for Lecture 6**

For each: draw the coordinate frames, determine the DH parameters, and give the transformation matrix *Ai* and *T*

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