

STATE UNIVERSITY OF NEW YORK AT BUFFALO
Mechanical and Aerospace Engineering Department.

MAE 505 ROBOTICS

Homework 2

NAME: LENG-FENG LEE

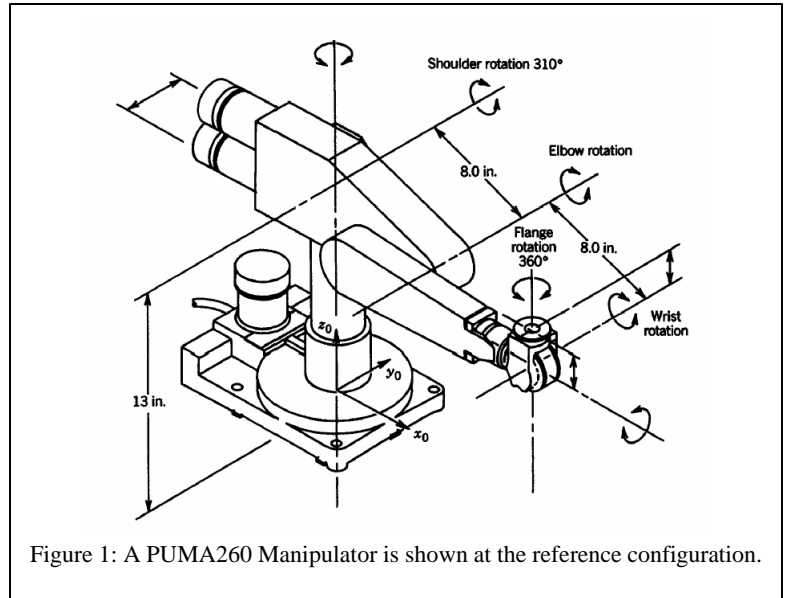
DATE: 15 Oct 2003.

THE DEPARTMENT OF MECHANICAL & AEROSPACE ENGINEERING
UNIVERSITY AT BUFFALO
MAE 505: Special Topics -- ROBOTICS, Fall 2003

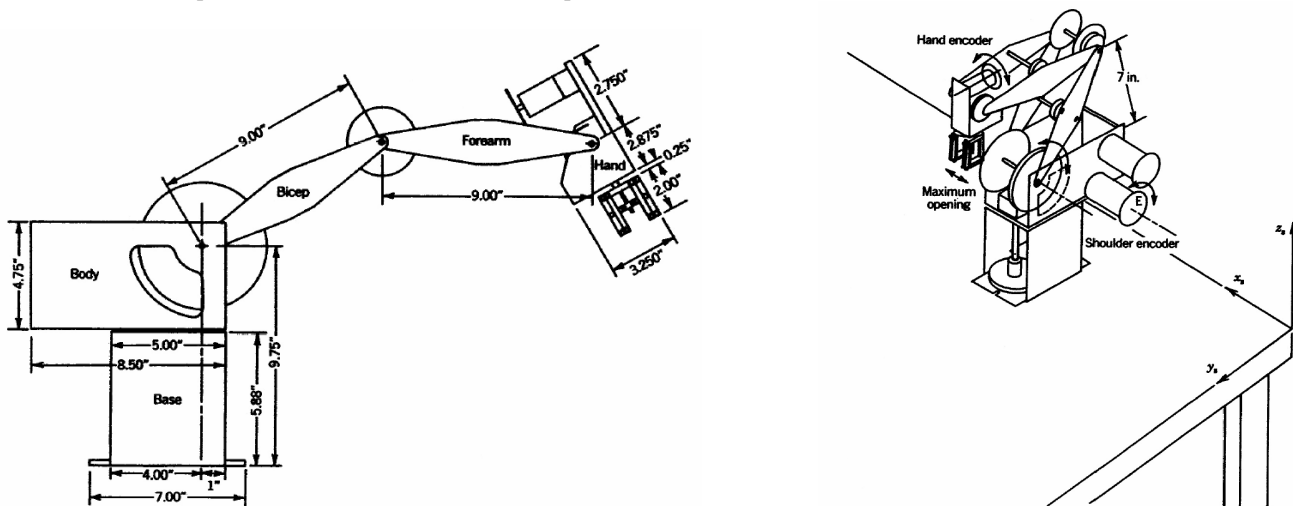
Homework #2: D-H Transformations and Manipulator Kinematics
Assigned on: October 6th 2003, Due: October 15th 2003, 11:00 AM

Prior to doing this exercise, please download the Robotics Toolbox for MATLAB from <http://www.cat.csiro.au/cmst/staff/pic/robot/>. Take the time to read through the detailed documentation and in particular to run the demo "rtdemo.m". At this stage you can safely ignore aspects related to the **forward and inverse dynamics** and focus on features pertaining to the initial creation of the "robot" object from "link" objects, the forward and inverse kinematics, the plotting and animation.

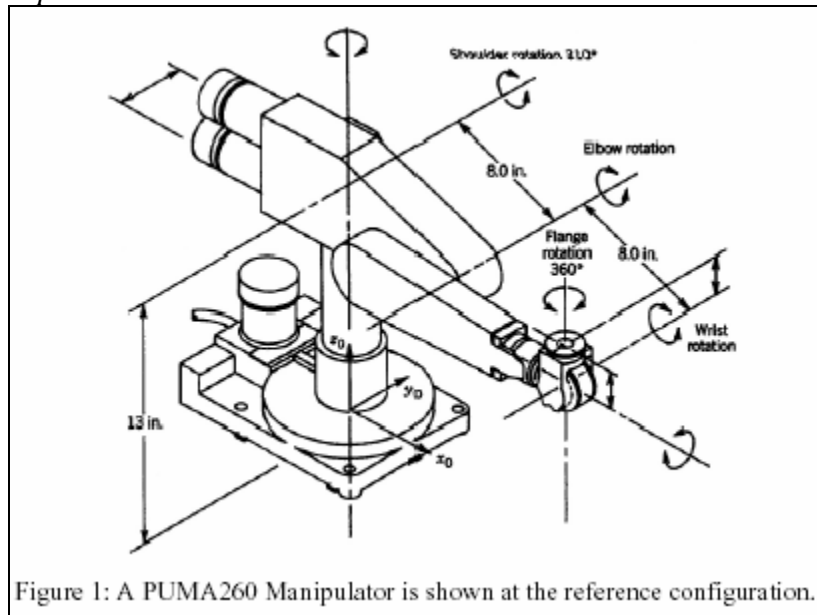
1. Consider the PUMA 260 manipulator in Figure 1.
 - (i) Derive the complete set of forward kinematics equations for the center of the wrist by establishing the DH frames, finding and taking the product of the corresponding homogenous transformations. Retain symbolic notation in terms of the only the link-lengths, a_i and the joint angles, q_i of D-H parameters.
 - (ii) The critical dimensions are noted in the Figure 1 and you may assume values for other dimensions (if necessary). Ignore the range of motion given for the shoulder rotation for this exercise. Using the Robotics Toolbox (or by writing your own MATLAB code using the forward kinematics equations) compute the workspace of the center of the wrist – i.e. move each preceding joint through its range of motion and plot the isometric view of the total workspace of the end-effector in 3D-Space as well as the three Cartesian projections of this workspace volume onto the XY, YZ and XZ planes.



2. Consider the Rhino manipulator in Figure 2.
 - (i) Derive the complete set of forward kinematics equations for the distal end of the bicep by establishing the DH frames, finding and taking the product of the corresponding homogenous transformations. Retain symbolic notation in terms of the only the link-lengths, a_i and the joint angles, q_i , of D-H parameters.
 - (ii) The critical dimensions are noted in the Figure 2 below. You may assume values for other dimensions (if necessary) and ignore any ranges of motion given for this exercise. Using the Robotics Toolbox (or by writing your own MATLAB code using the forward kinematics equations) compute the workspace of the distal end of the Bicep – i.e. move each preceding joint through its range of motion and plot the isometric view of the total workspace of the end-effector in 3D-Space as well as the three Cartesian projections of this workspace volume onto the XY, YZ and XZ planes.



Problem 1, 2nd part:



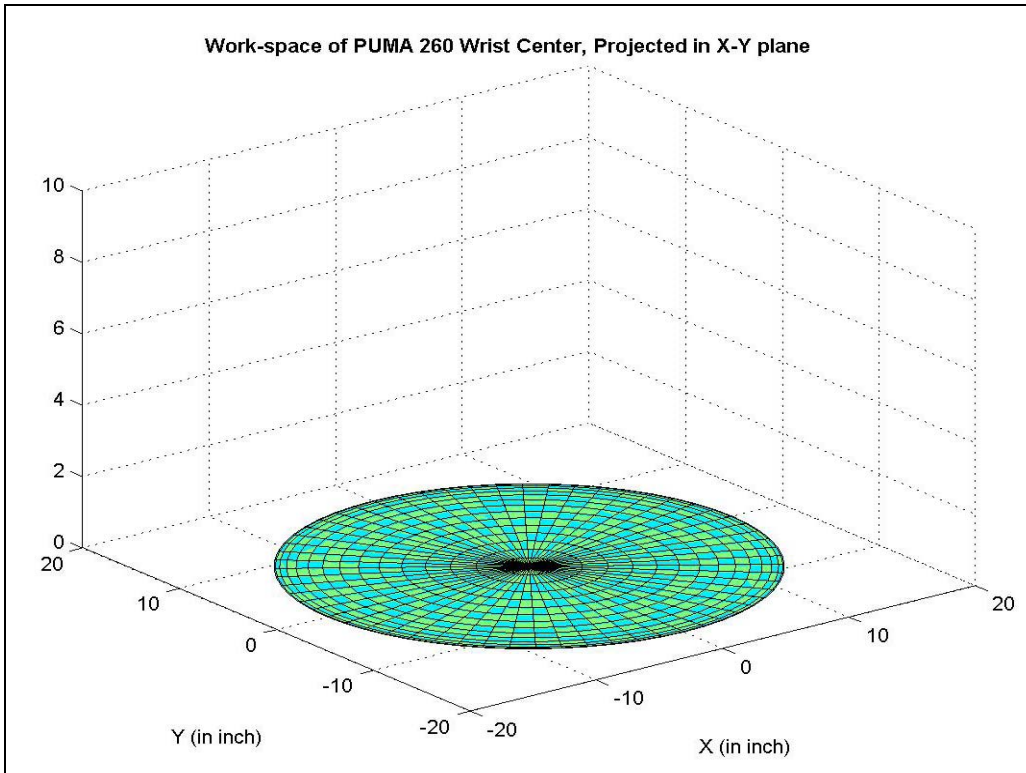
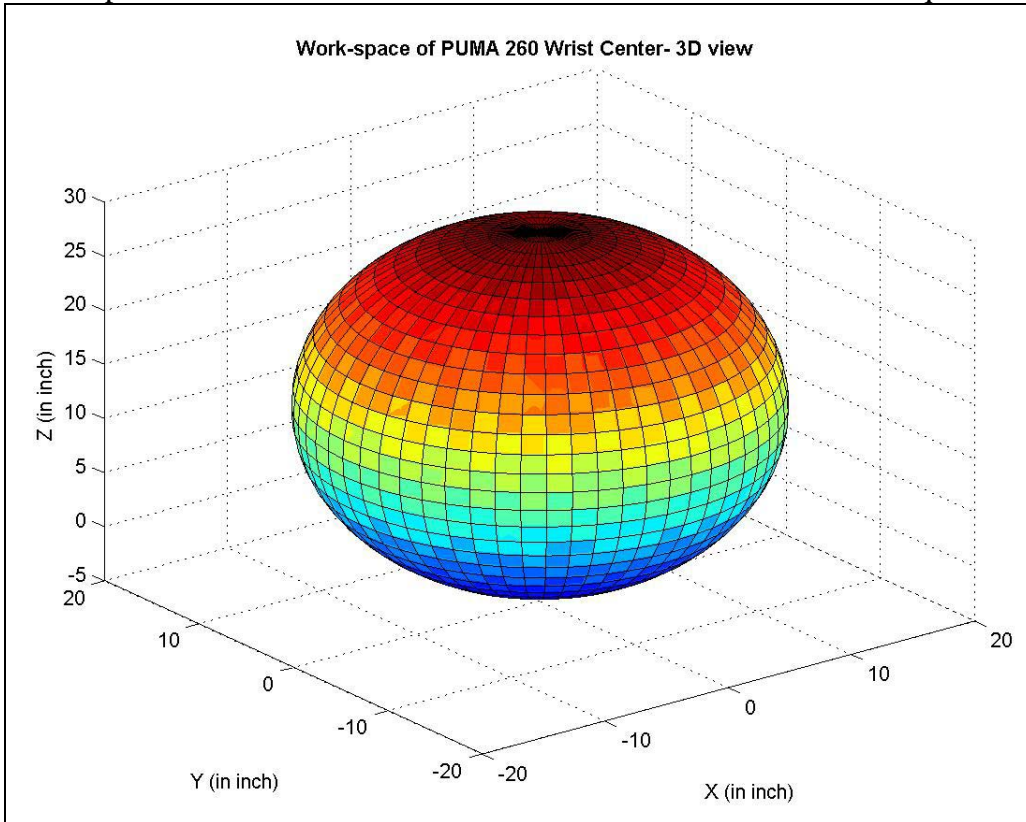
Question:

The critical dimensions are noted in the Figure 1 and you may assume values for other dimensions (if necessary). Ignore the range of motion given for the shoulder rotation for this exercise. Using the Robotics Toolbox (or by writing your own MATLAB code using the forward kinematics equations) compute the workspace of the center of the wrist – i.e. move each preceding joint through its range of motion and plot the isometric view of the total workspace of the end-effectors in 3DSpace as well as the three Cartesian projections of this workspace volume onto the XY, YZ and XZ planes.

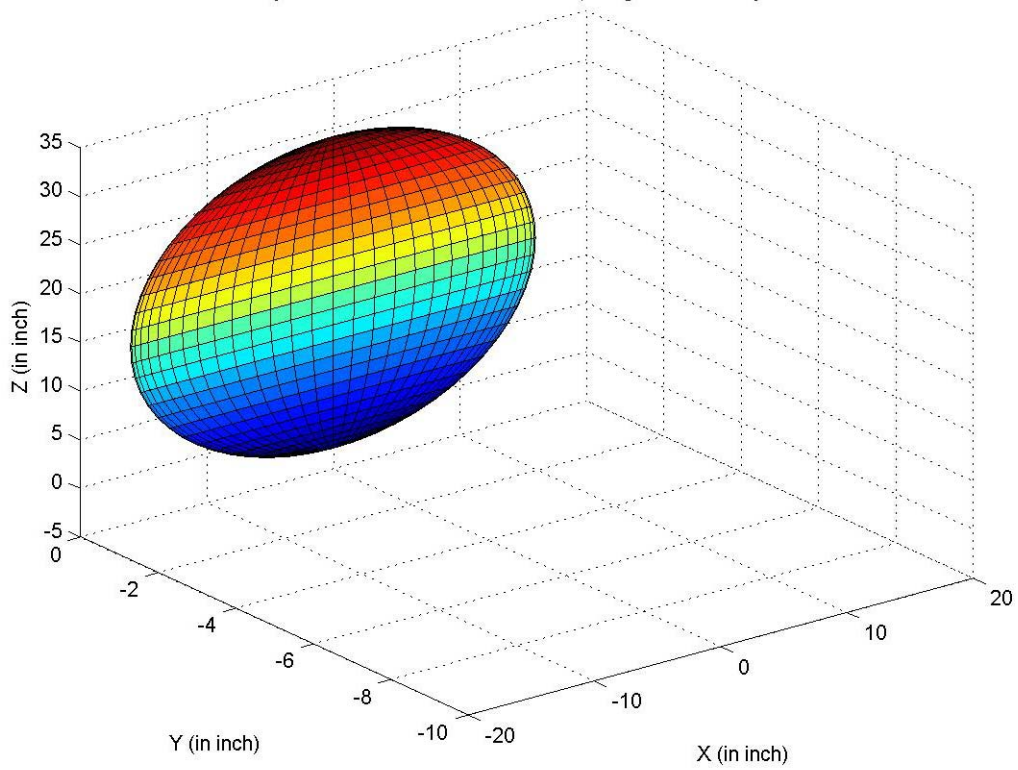
Solution for problem 1:

Solve this question by using Matlab's Robotic Toolbox. First create a robot object, used the forward kinematics function provided (`fkine()`) to calculate the end-effector position. Finally, plot the end-effector position using Matlab `surf()` function. Here, to calculate the workspace, we can fix θ_3 and varied θ_1 and θ_2 to calculate the end-effector position. The Matlab code and the results were shown below:

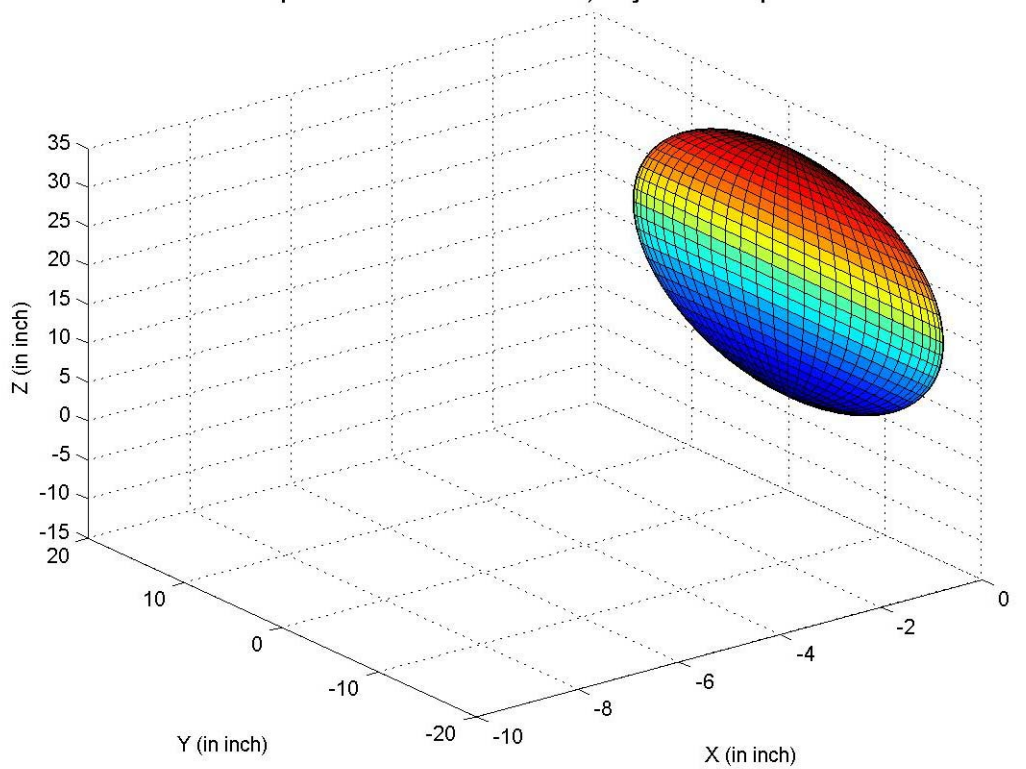
Work-Space of PUMA 260 wrist center is shown below for different requirements:



Work-space of PUMA 260 Wrist Center, Projected in X-Z plane



Work-space of PUMA 260 Wrist Center, Projected in Y-Z plane



Problem #2, 2nd part:

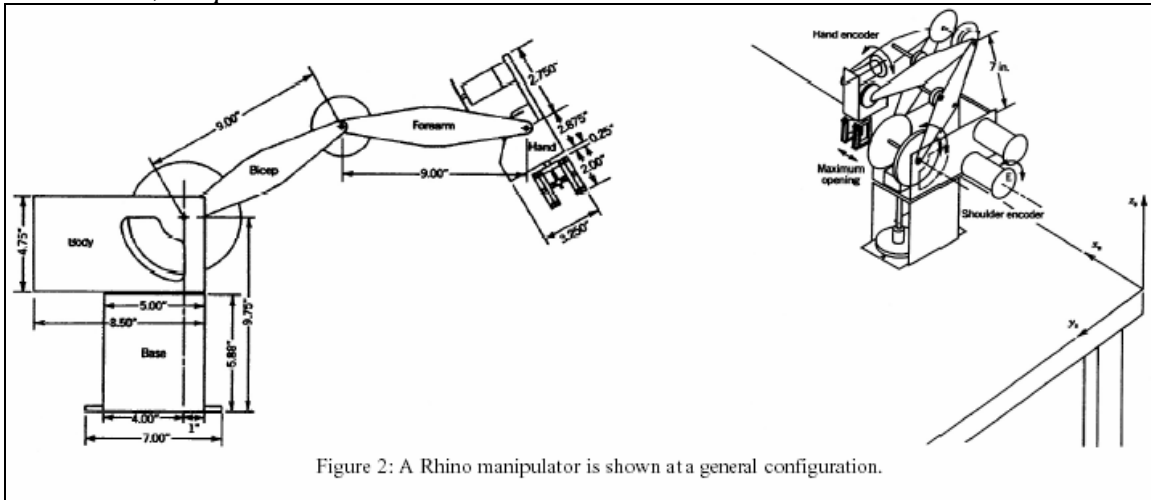


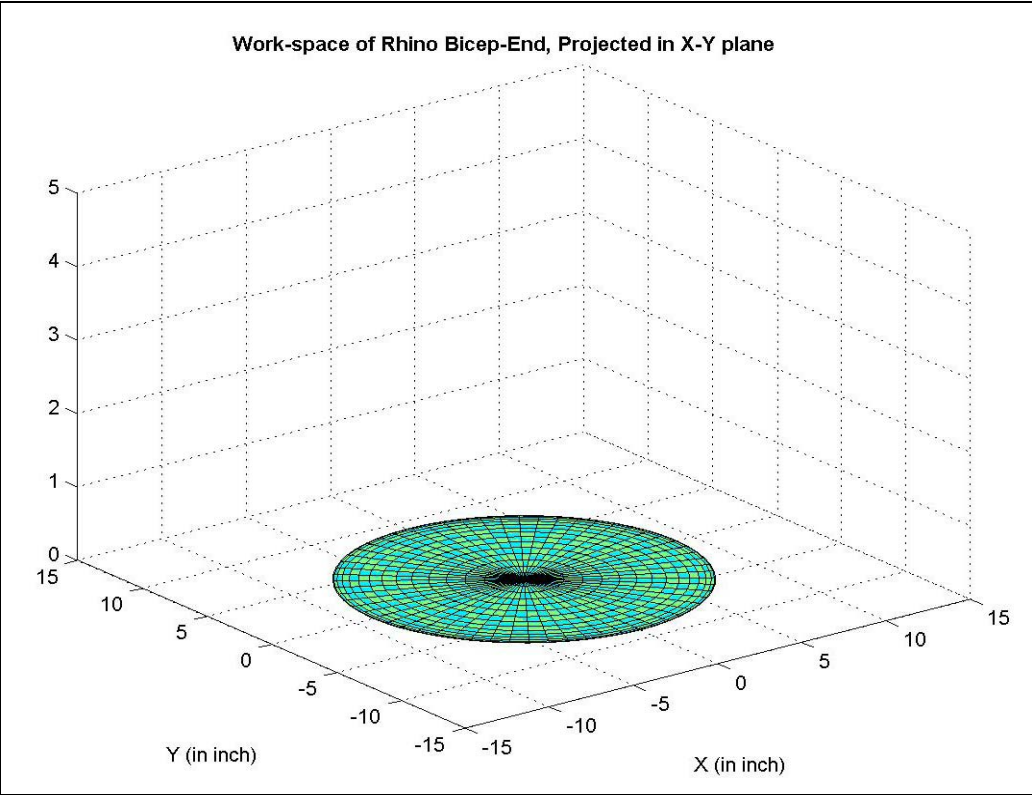
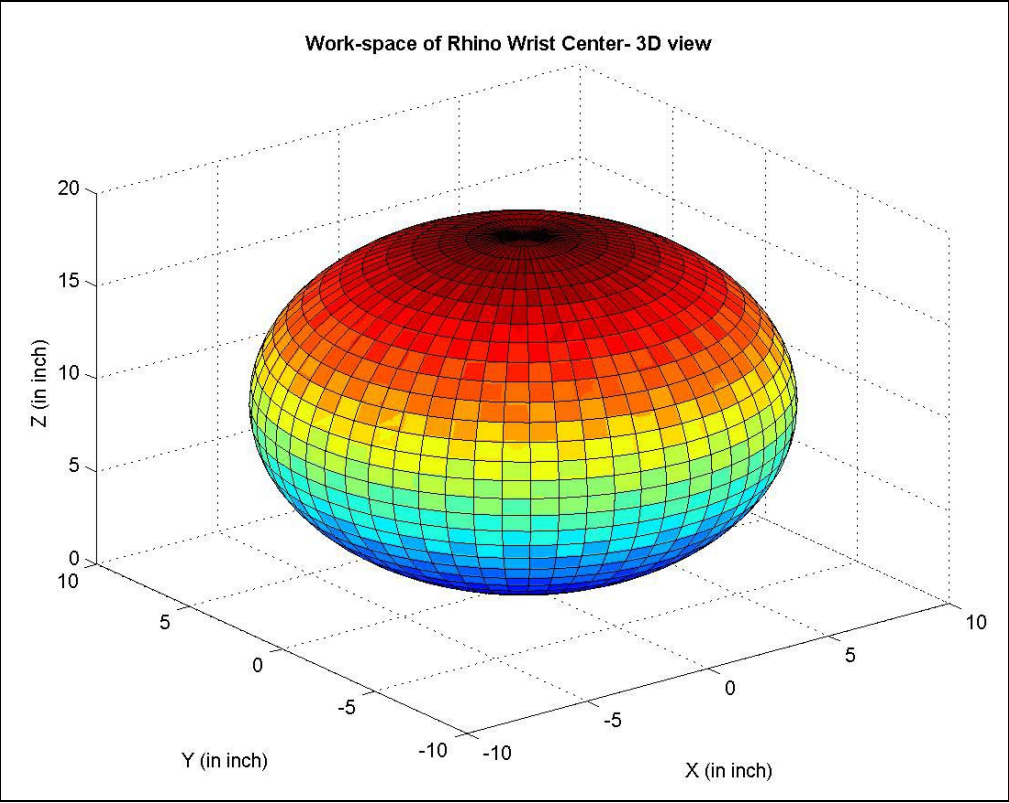
Figure 2: A Rhino manipulator is shown at a general configuration.

Question:

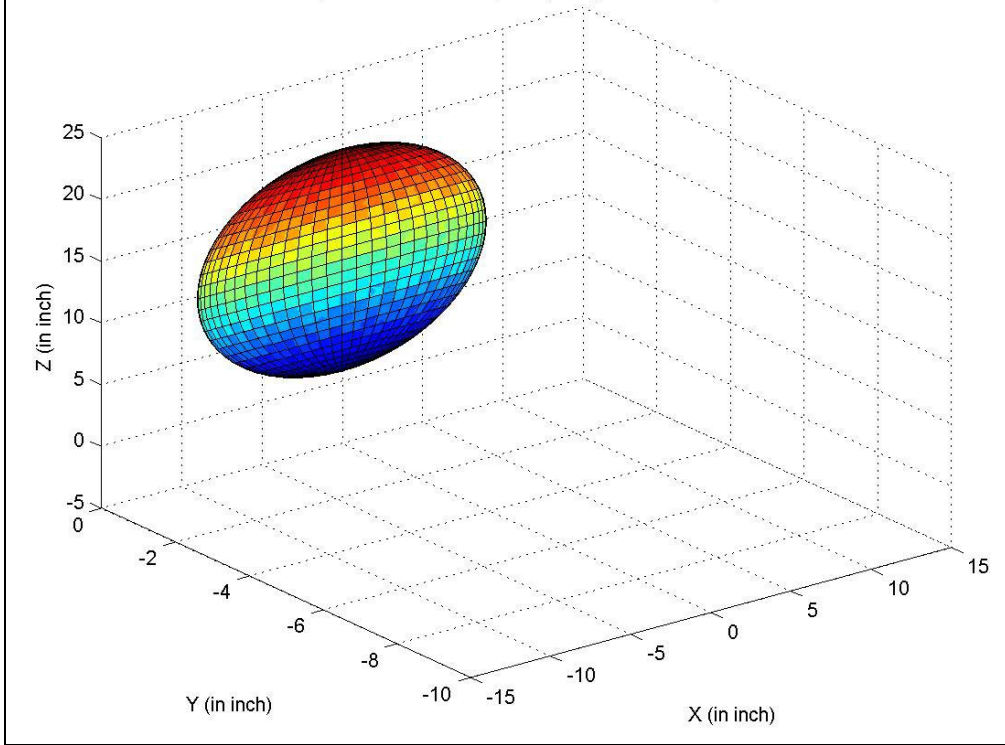
The critical dimensions are noted in the Figure 2 below. You may assume values for other dimensions (if necessary) and ignore any ranges of motion given for this exercise. Using the Robotics Toolbox (or by writing your own MATLAB code using the forward kinematics equations) compute the workspace of the distal end of the Bicep – i.e. move each preceding joint through its range of motion and plot the isometric view of the total workspace of the end-effector in 3D-Space as well as the three Cartesian projections of this workspace volume onto the XY, YZ and XZ planes.

Solution for problem 2:

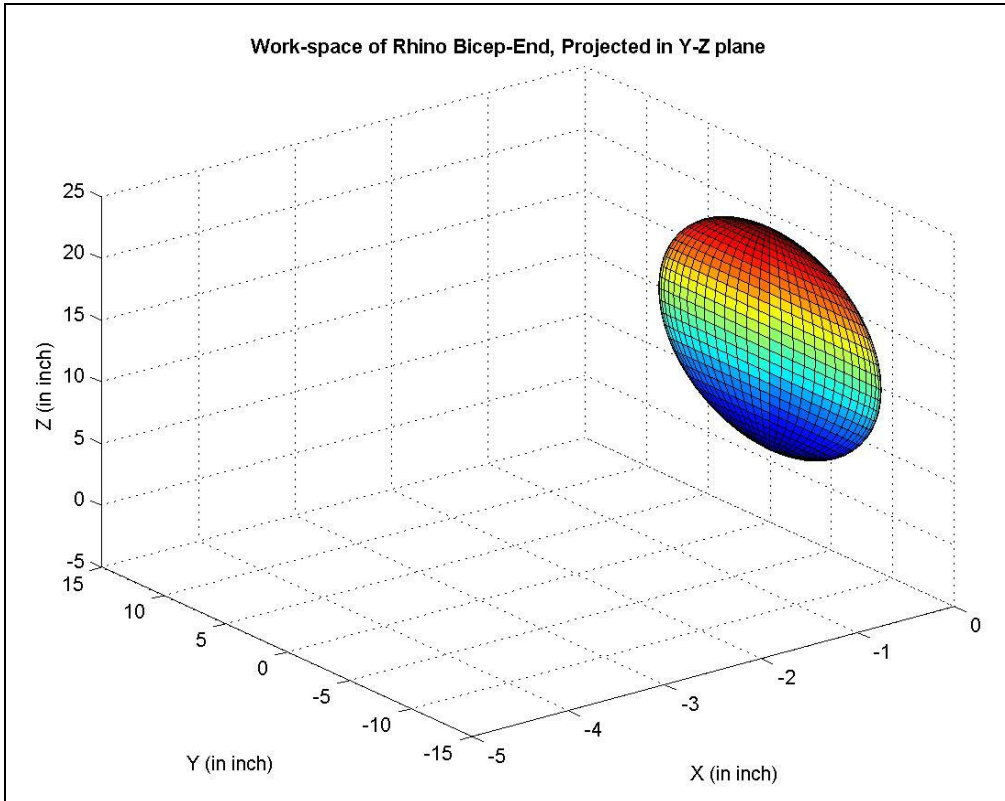
Similar to the first problem, solve this question by using Matlab's Robotic Toolbox. First create a robot object, used the forward kinematics function provided (fkine()) to calculate the end-effector position. Finally, plot the end-effector position using Matlab surf() function. The Matlab code and the results were shown below:



Work-space of Rhino Bicep-End, Projected in X-Z plane



Work-space of Rhino Bicep-End, Projected in Y-Z plane



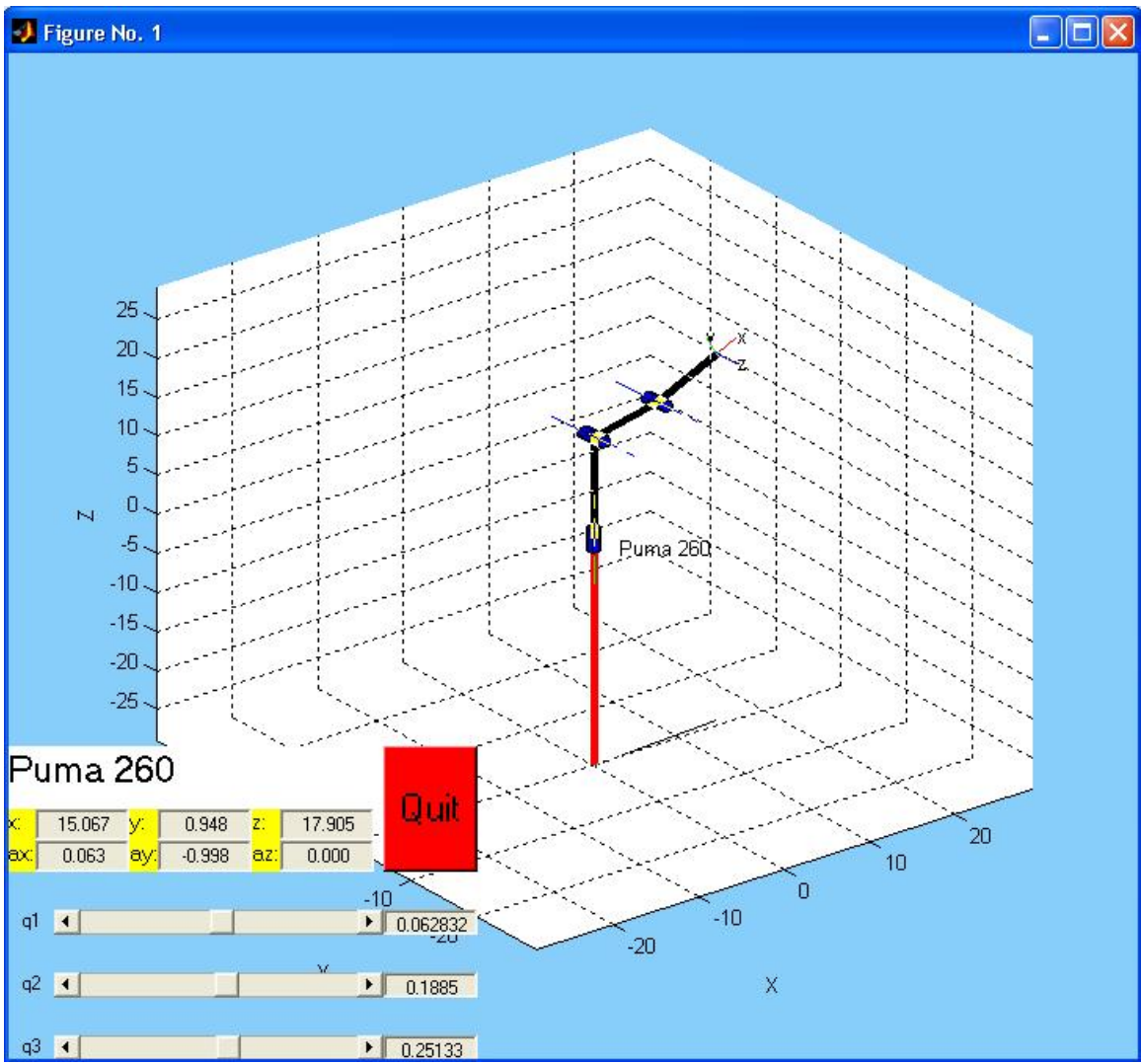


Figure No. 1

