EENG 428 Introduction to Robotics Laboratory

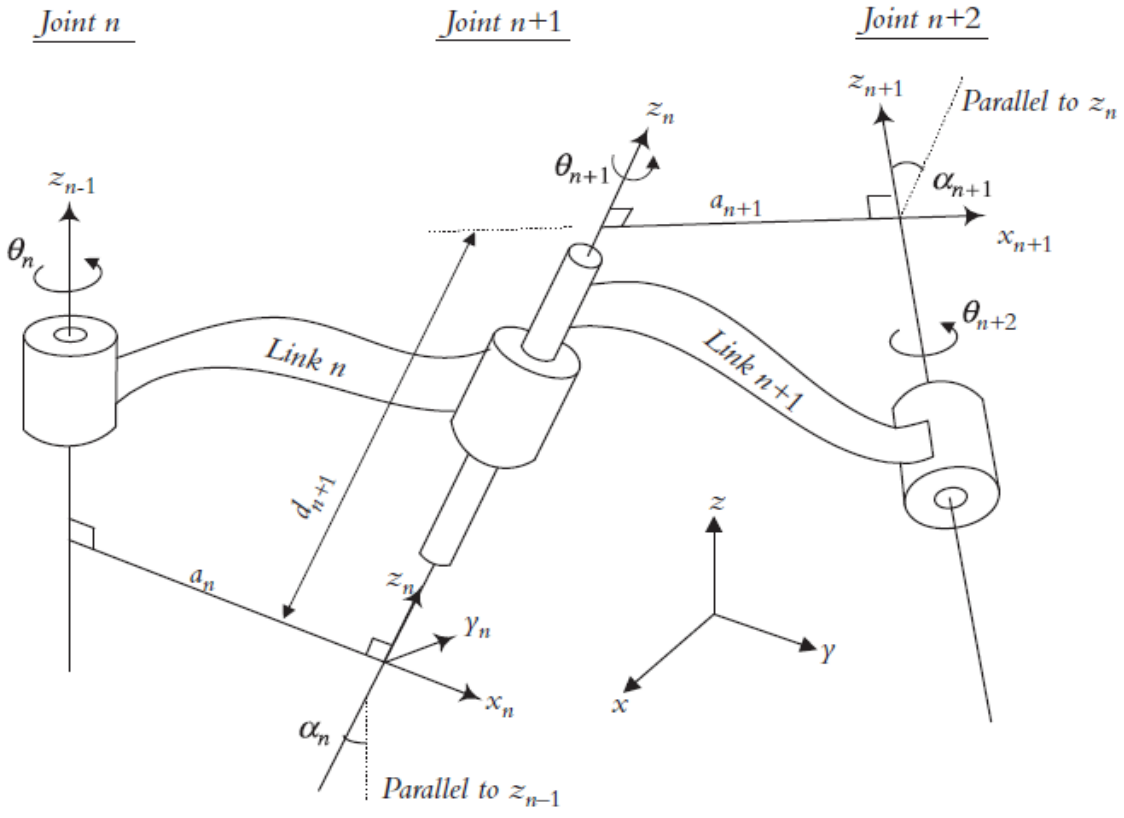
Lab Session 5

Objective

In this Lab session, Examples demonstrate the utility of Denavit-Hartenberg Representation to solve the Forward Kinematic Equations for the serial manipulators. Matlab program will be used to serve the purpose of this session.

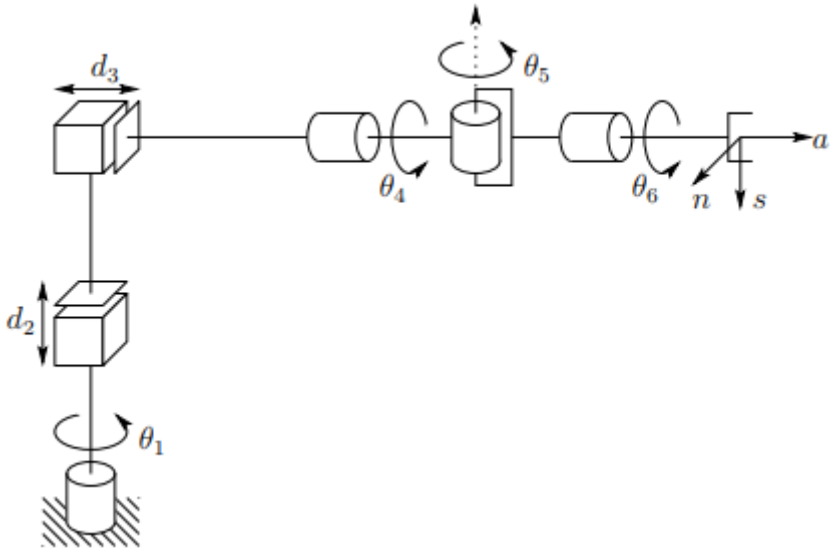
Denavit-Hartenberg Representation

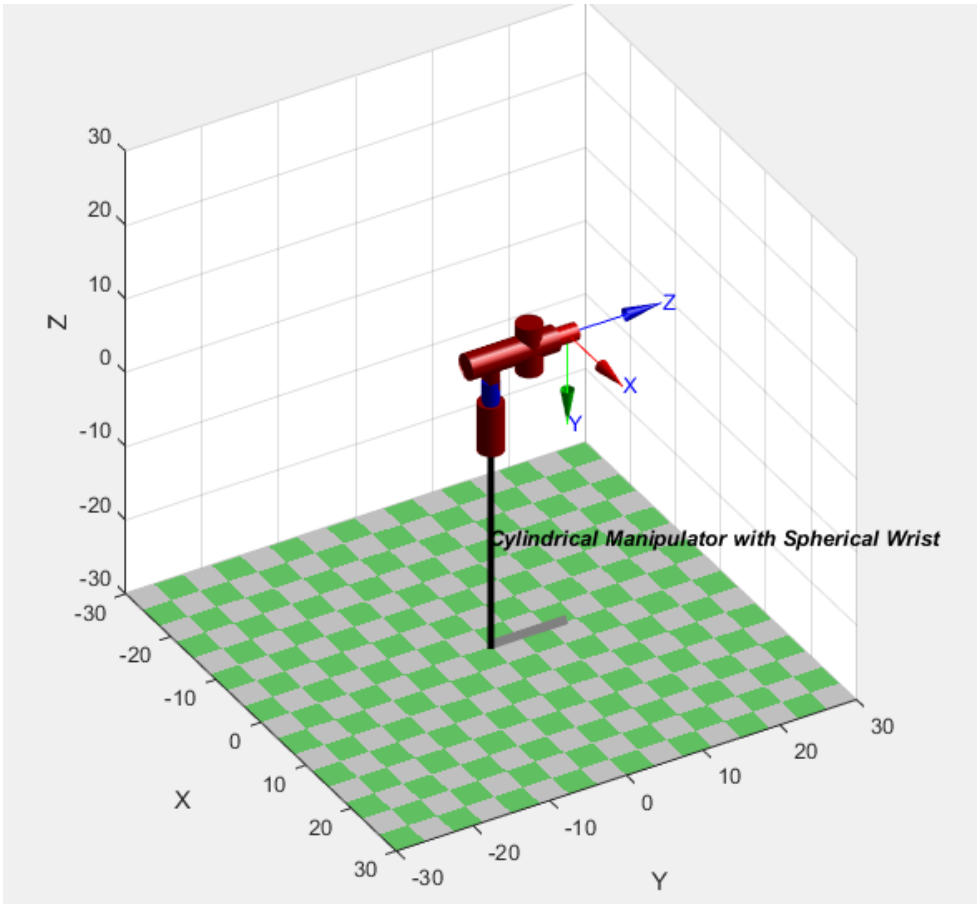
Denavit-Hartenberg convention is used to facilitate and standardize the way of representing two or more sequential frames of serial robotic manipulators. To model the robot with the D-H representation, we need to define the general procedure to assign reference frames to each joint. Then we will define how a transformation between any two successive frames may be accomplished. Finally, we will write the total transformation matrix for the robot. The following figure shows three joints. Each joint may be rotate or translate.



1- Cylindrical Manipulator with Spherical Wrist

Suppose that we attach a spherical wrist to the cylindrical manipulator as shown in the following Figure

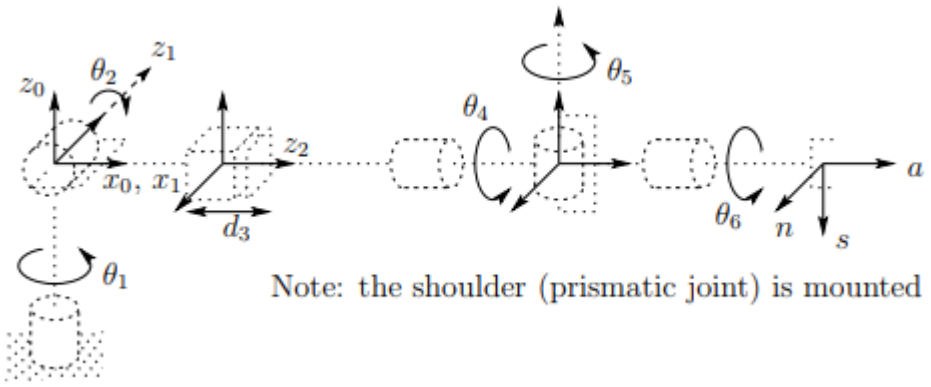




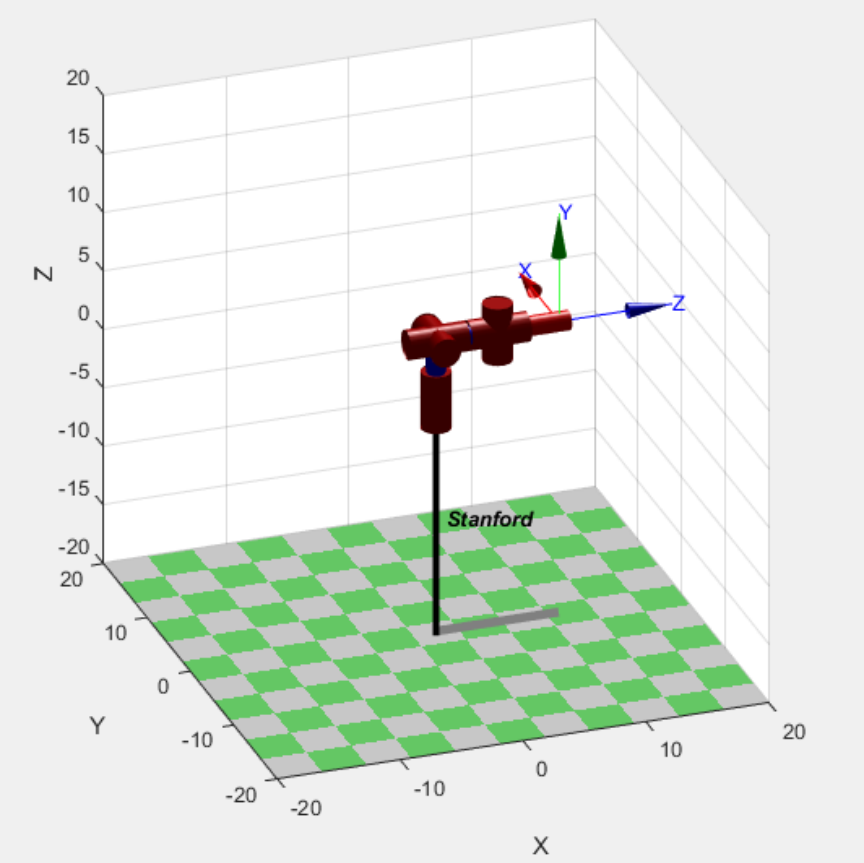
```
clc
clear all
d1=5;
d4=5;
d6=5;
L(1)=Link([0 d1 0 0 ])
L(2)=Link([0 0 0 -pi/2 1])
L(3)=Link([0 0 0 0 1])
L(4)=Link([0 d4 0 pi/2 ])
L(5)=Link([0 0 0 -pi/2 ])
L(6)=Link([0 d6 0 0 ])

R=SerialLink(L,'qlim',[-pi pi; 0 8;0 8;-pi pi;-pi/2
pi/2;-pi pi])
R.name='Cylindrical Manipulator with Spherical
Wrist';
plot(R,[0 0 0 0 0 0],'workspace',[-30 30 -30 30 -30
30])
teach(R)
```

2- Stanford Manipulator

Consider the Stanford Manipulator shown in Figure. This manipulator is an example of a spherical (RRP) manipulator with a spherical wrist.



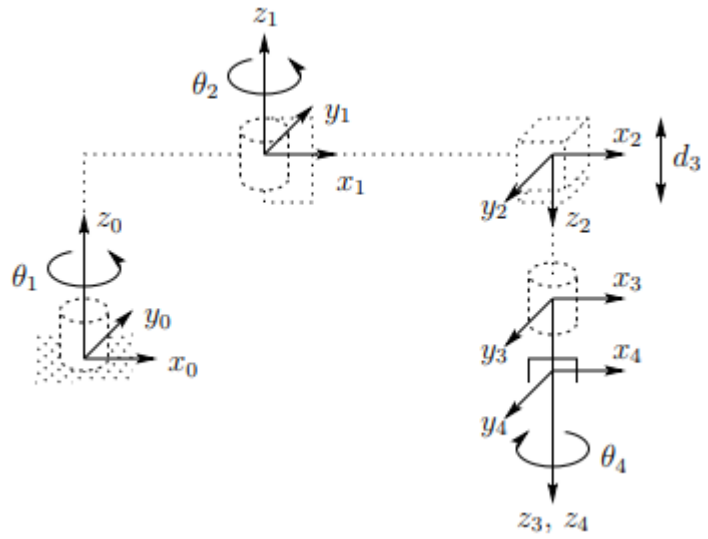
Note: the shoulder (prismatic joint) is mounted wrong.

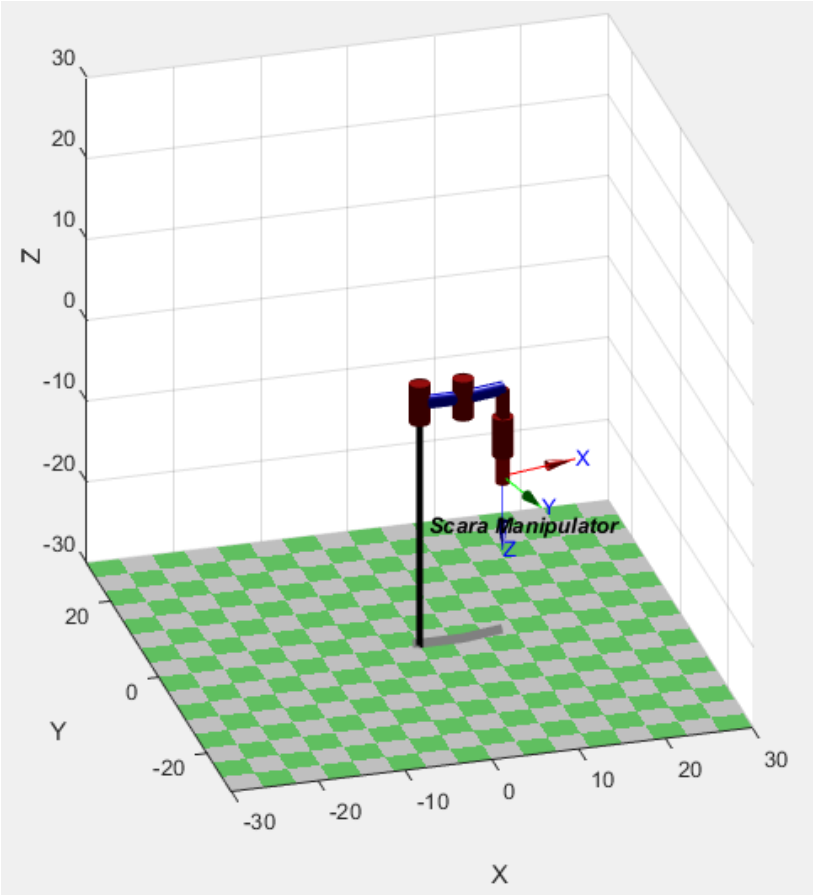



```
clc
clear all
d1=5;
d4=5;
d6=5;
L(1)=Link([0 d1 0 -pi/2 ])
L(2)=Link([0 0 0 -pi/2  0  -pi/2])
L(3)=Link([0 0 0 0 1])
L(4)=Link([0 d4 0 -pi/2  0  -pi/2])
L(5)=Link([0 0 0 pi/2 ])
L(6)=Link([0 d6 0 0 ])

R=SerialLink(L,'qlim',[-pi pi; -pi/4 pi/4;0 8;-pi pi;-
pi/2 pi/2;-pi pi])
R.name='Stanford';
plot(R,[0 0 0 0 0 0],'workspace',[-20 20 -20 20 -20 20])
teach(R)
```

3- SCARA Manipulator

consider the SCARA manipulator in the following Figure. This manipulator, consists of an RRP arm and a one degree of-freedom wrist, whose motion is a roll about the vertical axis.





```
clc
clear all
a1=5;
a2=5;
d4=5;

L(1)=Link([0 0 a1 0 ])
L(2)=Link([0 0 a2 pi])
L(3)=Link([0 0 0 0 1])
L(4)=Link([0 d4 0 0])

R=SerialLink(L,'qlim',[-pi pi; -pi/2 pi/2;0 8;-pi pi])
R.name='Scara Manipulator';
plot(R,[0 0 0 0],'workspace',[-30 30 -30 30 -30 30])
teach(R)
```