ME406: Robotics II
Homework 12
Due: 4/23/2021 (Friday)

The Denso VP-6242 with SMC MHS3-25D Pneumatic Gripper is pictured below in the zeroed configuration. Below this, the individual links of the robot are shown and the location of the next link's body-fixed frame are described along with the mass parameters of the links.

Using this information:

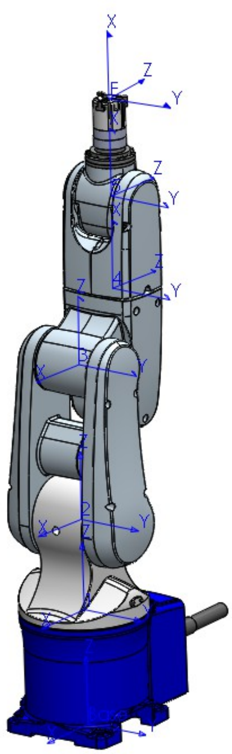
1. Create a function called VP_6242_draw that accepts a vector of joint angles and draws the robot in the specified configuration (you should already have most of this from last year but pay attention to the end-effector). The .stl files for this robot are in the "Denso VP 6242" folder on Canvas and are in <u>units of millimeters.</u>

2. Create a function called VP_6242 that accepts a vector of joint angles and joint velocities and a vector of joint torques and returns a vector of the joint velocities and joint accelerations. Compute the joint accelerations using the recursive kinematics and the Newton-Euler equations.

3. Create a script called VP_6242_solver, that implements a 4^{th} order Runge-Kutta numerical integrator to solve the equations of motion that are implemented in 2 in response to an applied joint torque vector and initial conditions. The script should also generate a figure window depicting the joint trajectories and should animate the robot.

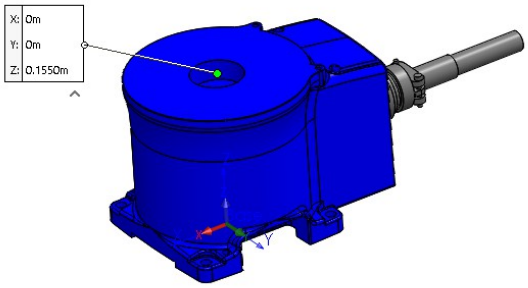
Demonstrate the working code above.

Zeroed Configuration:

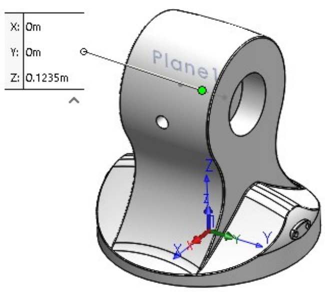


Base:

$$
{}^{I}_{I}\boldsymbol{r}_1 = \begin{bmatrix} 0 \\ 0 \\ 0.1550 \end{bmatrix} \ (m)
$$



Link 1:



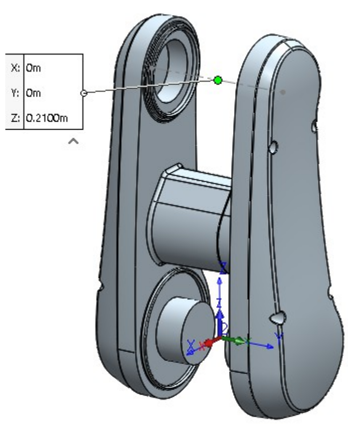
$$
m_1 = 1.67711788 \ (kg)
$$

$$
{}^{1}_{1}\boldsymbol{\Gamma} = \begin{bmatrix} 0.00000000 \\ 0.00000000 \\ 0.06531164 \end{bmatrix} m_1 \ (kg\, m)
$$

$$
{}^{1}_{1}\boldsymbol{J} = \begin{bmatrix} 0.01385583 & -0.00000008 & 0.00000007 \\ -0.00000008 & 0.01366144 & 0.00000002 \\ 0.00000007 & 0.00000002 & 0.00342620 \end{bmatrix} \ (kg\, m^2)
$$

$$
{}^{1}_{1}\boldsymbol{r}_2 = \begin{bmatrix} 0 \\ 0 \\ 0.1235 \end{bmatrix} \ (m)
$$

Link 2:



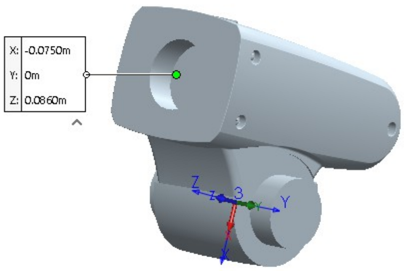
$$
m_2 = 2.18012904 \ (kg)
$$

$$
{}^{2}_{2}\boldsymbol{\Gamma} = \begin{bmatrix} 0.00319385 \\ 0.00002007 \\ 0.07568397 \end{bmatrix} m_2 \ (kg\, m)
$$

$$
{}^{2}_{2}\boldsymbol{J} = \begin{bmatrix} 0.03147084 & 0.00000021 & -0.00067801 \\ 0.00000021 & 0.02569684 & -0.00004077 \\ -0.00067801 & -0.00004077 & 0.00840044 \end{bmatrix} \ (kg\, m^2)
$$

$$
{}^{2}_{2}\boldsymbol{r}_3 = \begin{bmatrix} 0 \\ 0 \\ 0.2100 \end{bmatrix} \ (m)
$$

Link 3:



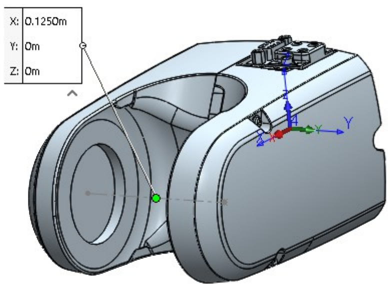
$$m_3 = 1.98159082 \ \left(kg\right)$$

$${}^{3}_{3}\boldsymbol{\Gamma} = \begin{bmatrix} -0.05649308 \\ 0.00000216 \\ 0.00002412 \end{bmatrix} m_3 \ \left(kg\,m\right)$$

$${}^{3}_{3}\boldsymbol{J} = \begin{bmatrix} 0.00000000 & 0.00000024, & .00000270 \\ 0.00000024 & 0.00632418 & -0.00000000 \\ 0.00000270 & -0.00000000 & 0.00632418 \end{bmatrix} \left(kg\,m^2\right)$$

$${}^{3}_{3}\boldsymbol{r}_4 = \begin{bmatrix} -0.0750 \\ 0 \\ 0.0860 \end{bmatrix} \ \left(m\right)$$

Link 4:



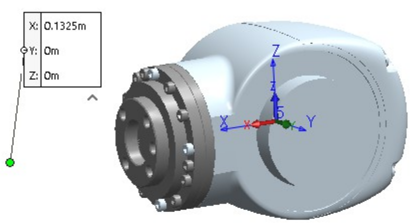
$$m_4 = 0.97810626 \ \left(kg\right)$$

$${}^{4}_{4}\boldsymbol{\Gamma} = \begin{bmatrix} 0.05529733 \\ 0.00040348 \\ 0.00007649 \end{bmatrix} m_4 \ \left(kg\,m\right)$$

$${}^{4}_{4}\boldsymbol{J} = \begin{bmatrix} 0.00175468 & -0.00004164 & -0.00000141 \\ -0.00004164 & 0.00521944 & -0.00000199 \\ -0.00000141 & -0.00000199 & 0.00585960 \end{bmatrix} \left(kg\,m^2\right)$$

$${}^{4}_{4}\boldsymbol{r}_5 = \begin{bmatrix} 0.1250 \\ 0 \\ 0 \end{bmatrix} \ \left(m\right)$$

Link 5:



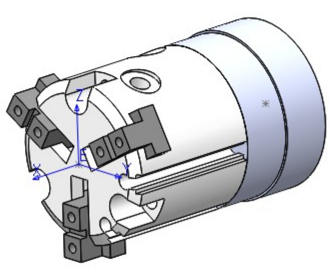
$$m_5 = 0.50552673 \ \left(kg\right)$$

$${}^{5}_{5}\boldsymbol{\Gamma} = \begin{bmatrix} 0.00389038 \\ -0.00058508 \\ 0.00000000 \end{bmatrix} m_5 \ \left(kg\,m\right)$$

$${}^{5}_{5}\boldsymbol{J} = \begin{bmatrix} 0.00037655 & -0.00000128 & -0.00000000 \\ -0.00000128 & 0.00066690 & -0.00000000 \\ -0.00000000 & -0.00000000 & 0.00065165 \end{bmatrix} \left(kg\,m^2\right)$$

$${}^{5}_{5}\boldsymbol{r}_E = \begin{bmatrix} 0.1325 \\ 0 \\ 0 \end{bmatrix} \ \left(m\right)$$

Link E:



$$m_E = 0.21423253 \ \left(kg\right)$$

$${}^{E}_{E}\boldsymbol{\Gamma} = \begin{bmatrix} -0.03296238 \\ -0.00037777 \\ 0.00003040 \end{bmatrix} m_6 \ \left(kg\,m\right)$$

$${}^{E}_{E}\boldsymbol{J} = \begin{bmatrix} 0.00004684 & -0.00000206 & -0.00000030 \\ -0.00000206 & 0.00033054 & -0.00000050 \\ -0.00000030 & -0.00000050 & 0.00033059 \end{bmatrix} \left(kg\,m^2\right)$$