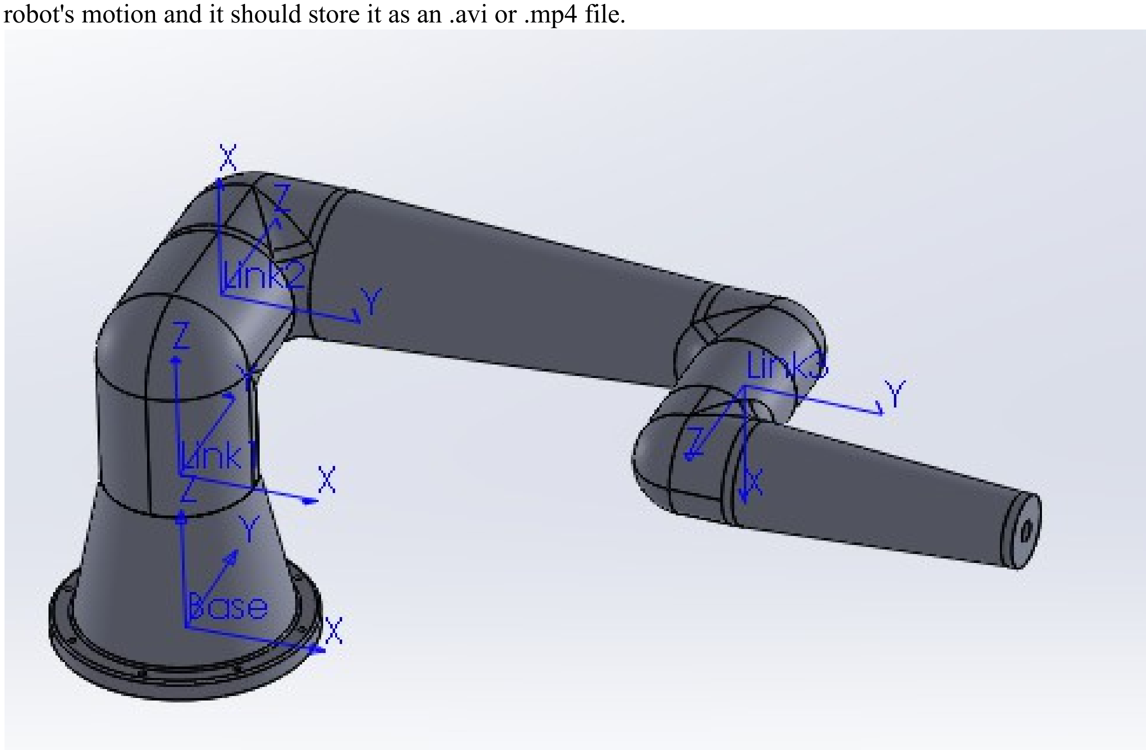
ME406: Robotics II
Homework 5
Demonstrate By: 5:00 pm, on 3/3/2021 (Wednesday)

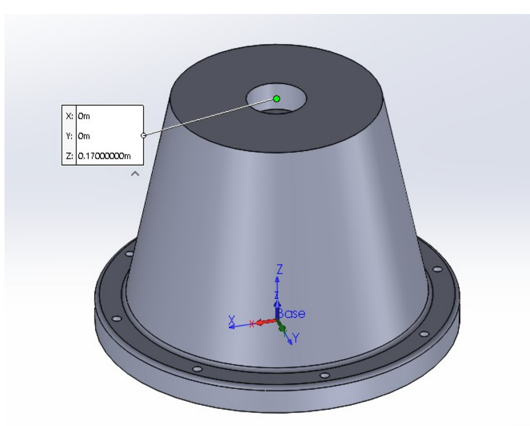
A three-link manipulator is depicted below in the zeroed configuration. The locations of subsequent link frames and the mass-parameters for each link follow. The .stl files for the links of this manipulator are located in the “Nabila” folder in the “files” section of the course Canvas site. Assuming that the base frame is an inertial frame, perform the following:

1) Create a MATLAB function called “Nabila_draw” that accepts a 3×1 vector of joint angles and draws the robot in the configuration specified by these joint angles.
2) Once the robot is drawn correctly, use the kinematics from 1) to create a MATLAB script called “Nabila_derivation” that generates the symbolic expressions for the system mass matrix, $\boldsymbol{H}(\boldsymbol{\gamma})$, the vector of Coriolis and centripetal forces, $\boldsymbol{d}(\boldsymbol{\gamma},\dot{\boldsymbol{\gamma}})$, and the vector of gravitational forces, $\boldsymbol{G}(\boldsymbol{\gamma})$.
3) Using the expressions generated in 2), create a MATLAB function called “Nabila” that accepts 6×1 vector of joint angles and joint velocities and a 3×1 vector of joint torques. The function should output a 6×1 vector of joint velocities and accelerations.
4) Create a MATLAB script called “Nabila_solver”. The script should integrate the equations of motion using a 4th order Runge-Kutta integrator. It should also create figure window consisting of three vertically stacked subplots which depict the each of the three joint angles vs. time. Furthermore, the script should create an animation of the robot's motion and it should store it as an .avi or .mp4 file.



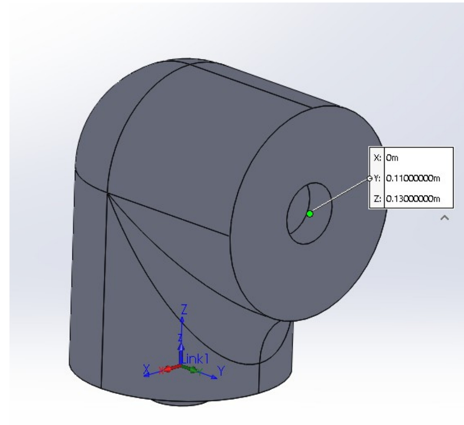
Base:

$${}^{B}_{B}\boldsymbol{r}_1 = \begin{bmatrix} 0 \\ 0 \\ 0.17 \end{bmatrix} (\mathrm{m})$$



Link 1:

$${}^{1}_{1}\boldsymbol{r}_2=\begin{bmatrix}0\\0.11\\0.13\end{bmatrix}\ \text{(m)}$$



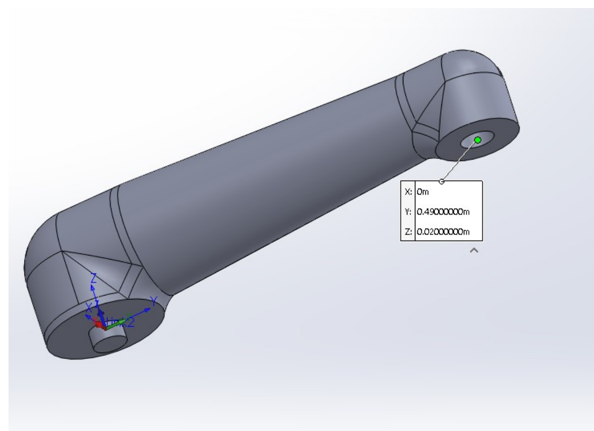
$$m_1=3.62564899\ \text{(kg)}$$

$${}^{1}_{1}\boldsymbol{r}_{cm}=\begin{bmatrix}0.00000000\\0.01906083\\0.09908556\end{bmatrix}\ \text{(m)}$$

$${}^{1}_{1}\boldsymbol{J}=\begin{bmatrix}0.05480945 & -0.00000000 & -0.00000000\\-0.00000000 & 0.05032975 & -0.00906068\\-0.00000000 & -0.00906068 & 0.01339125\end{bmatrix}\ (\text{kg m}^2)$$

Link 2:

$${}^{2}_{2}\boldsymbol{r}_3=\begin{bmatrix}0\\0.49\\0.02\end{bmatrix}\ \text{(m)}$$



$$m_2=7.28910514\ \text{(kg)}$$

$${}^{2}_{2}\boldsymbol{r}_{cm}=\begin{bmatrix}0.00000000\\0.19160707\\0.07507103\end{bmatrix}\ \text{(m)}$$

$${}^{2}_{2}\boldsymbol{J}=\begin{bmatrix}0.52173834 & 0.00000010 & -0.00000005\\0.00000010 & 0.05685904 & -0.10835509\\-0.00000005 & -0.10835509 & 0.47943980\end{bmatrix}\ (\text{kg m}^2)$$

Link 3:

$$m_3=2.96056704\ \text{(kg)}$$

$${}^{3}_{3}\boldsymbol{r}_{cm}=\begin{bmatrix}0.00000000\\0.08913956\\0.10830011\end{bmatrix}\ \text{(m)}$$

$${}^{3}_{3}\boldsymbol{J}=\begin{bmatrix}0.09409322 & -0.00000000 & -0.00000000\\-0.00000000 & 0.04215810 & -0.03432580\\-0.00000000 & -0.03432580 & 0.05516869\end{bmatrix}\ (\text{kg m}^2)$$