RBE- 501 HW4 REPORT
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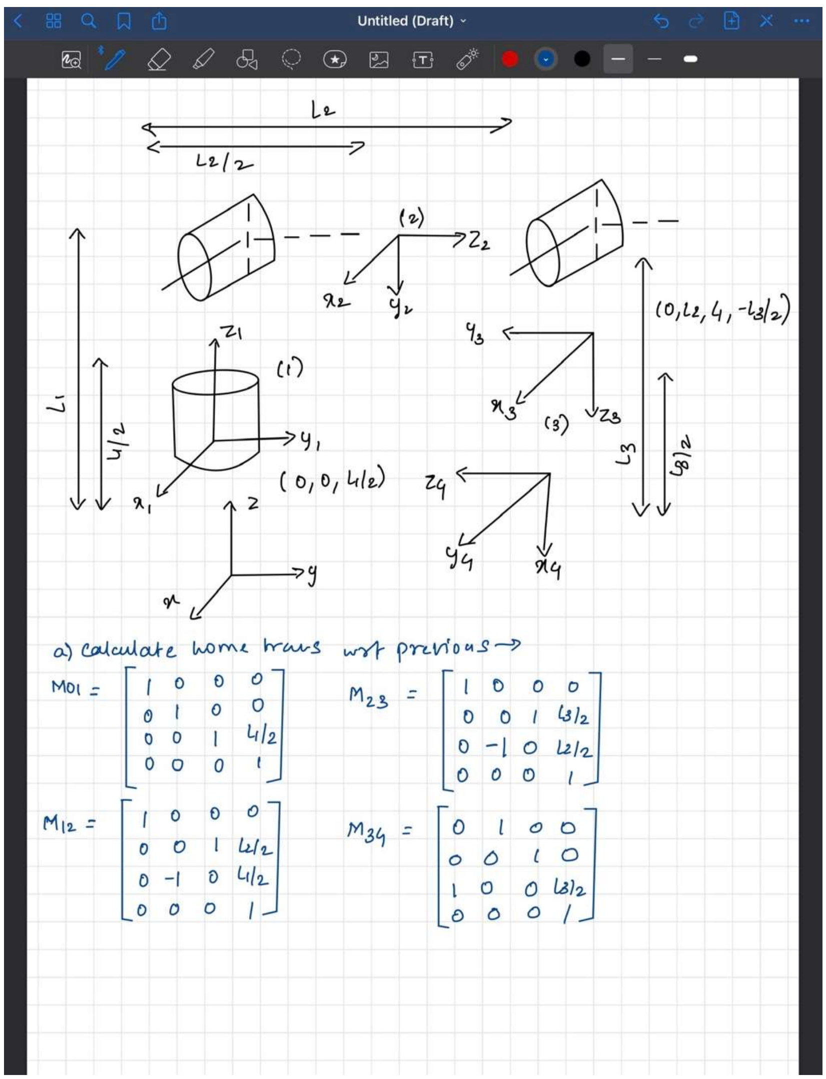
Listed are the steps followed to solve HW4 of Robot Dynamics RBE-501 Fall 2022

Problem 1:

a) Homogeneous transformation matrices representing the pose of each frame are calculated with respect to the previous one as follows and entered them into MATLAB.



b) The special inertia matrices will only have Im to be the non-zero, rest all values are zero. It is as follows:

b)

$$G_1 = \begin{bmatrix} 0_{3\times3} & 0 \\ 0_{3\times3} & \begin{matrix} m_1 & 0 & 0 \\ 0 & m_1 & 0 \\ 0 & 0 & m_1 \end{matrix} \end{bmatrix} \qquad G_2 = \begin{bmatrix} 0_{3\times 3} & 0 \\ 0 & \begin{matrix} m_2 & 0 & 0 \\ 0 & m_2 & 0 \\ 0 & 0 & m_2 \end{matrix} \end{bmatrix} \qquad G_3 = \begin{bmatrix} 0 & 0 \\ 0 & \begin{matrix} m_3 & 0 & 0 \\ 0 & m_3 & 0 \\ 0 & 0 & m_3 \end{matrix} \end{bmatrix}$$

since $G = \begin{bmatrix} \mathcal{J} & 0_{3\times3} \\ 0_{3\times3} & m_i I \end{bmatrix}$ in this case, $\mathcal{J} = 0$

c) An animation of the robot collapsing under its own weight can be observed.

d) The home configuration shows the robot standing still.

e) A simulation of the robot moving along the prescribed trajectory can be observed.

The Joint Torques were displayed in a graph form as follows:

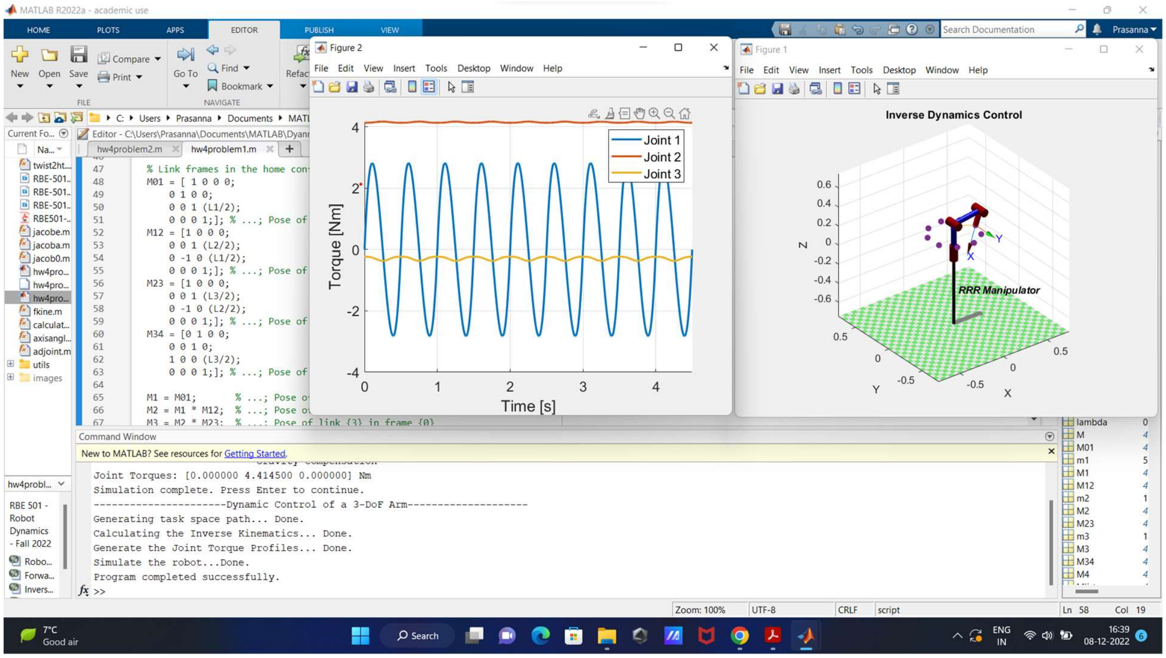


Figure 1: Results when Robot has no Rotational Inertia

This is considering that the value of rotational inertia is zero (as mentioned in the part b). It is seen in the Torque Vs Time graph that Joint 1 has initial and final velocity to be zero and has even acceleration and deceleration. Moreover, Joint 2 has a on a constant velocity, and Joint 3 has a negative velocity.

f) Then, the value of rotational inertia is calculated by using Ixx, Iyy, and Izz values given in the problem.

f) calculating the spatial Inertia Matrices –

$$I_{xx} = m(w^2+h^2)/12$$
$$I_{yy} = m(l^2+h^2)/12$$
$$I_{zz} = m(l^2+w^2)/12$$

For G_1,

$$I_{xx} = 5((0.04)^2+(0.3)^2)/12 = 0.0382$$
$$I_{yy} = 5((0.04)^2+(0.3)^2)/12 = 0.0382$$
$$I_{zz} = 5((0.04)^2+(0.04)^2)/12 = 0.0013$$

For G_2,

$$I_{xx} = ((0.04)^2+(0.3)^2)/12 = 0.076$$
$$I_{yy} = ((0.04)^2+(0.3)^2)/12 = 0.076$$
$$I_{zz} = ((0.04)^2+(0.04)^2)/12 = 0.0026$$

For G_3,

$$I_{xx} = ((0.04^2+(0.15)^2)/12 = 0.002$$
$$I_{yy} = ((0.04)^2+(0.15)^2)/12 = 0.002$$
$$I_{zz} = ((0.04)^2+(0.04)^2)/12 = 0.0026$$

∴ For each G, the spacial inertia matrix can be given as:

$$G = \begin{bmatrix} \begin{matrix} I_{xx} & 0 & 0 \\ 0 & I_{yy} & 0 \\ 0 & 0 & I_{zz} \end{matrix} & 0_{3\times3} \\ 0_{3\times3} & I_m \end{bmatrix}$$

The Joint Torques were displayed in a graph form as follows:

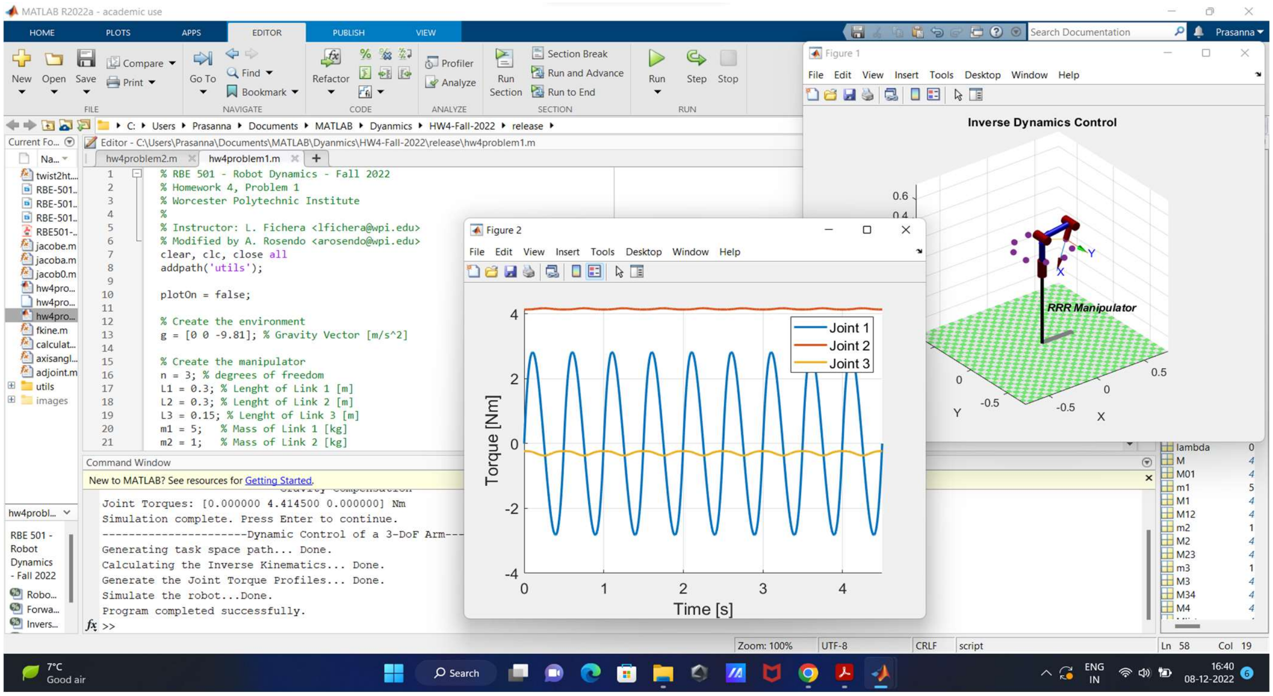


Figure 2: Results with calculated Spatial Inertia Matrices

The acceleration and deceleration of Joint 1 shows increase in values, remaining two joint velocities remain the same.

g) The robot bears a load of 1Kg at its end-effector, so the screw matrix is added to the Tooltip force. The screw matrix: [0 0 0 -0.981 0 0]

The Joint Torques were displayed in a graph form as follow

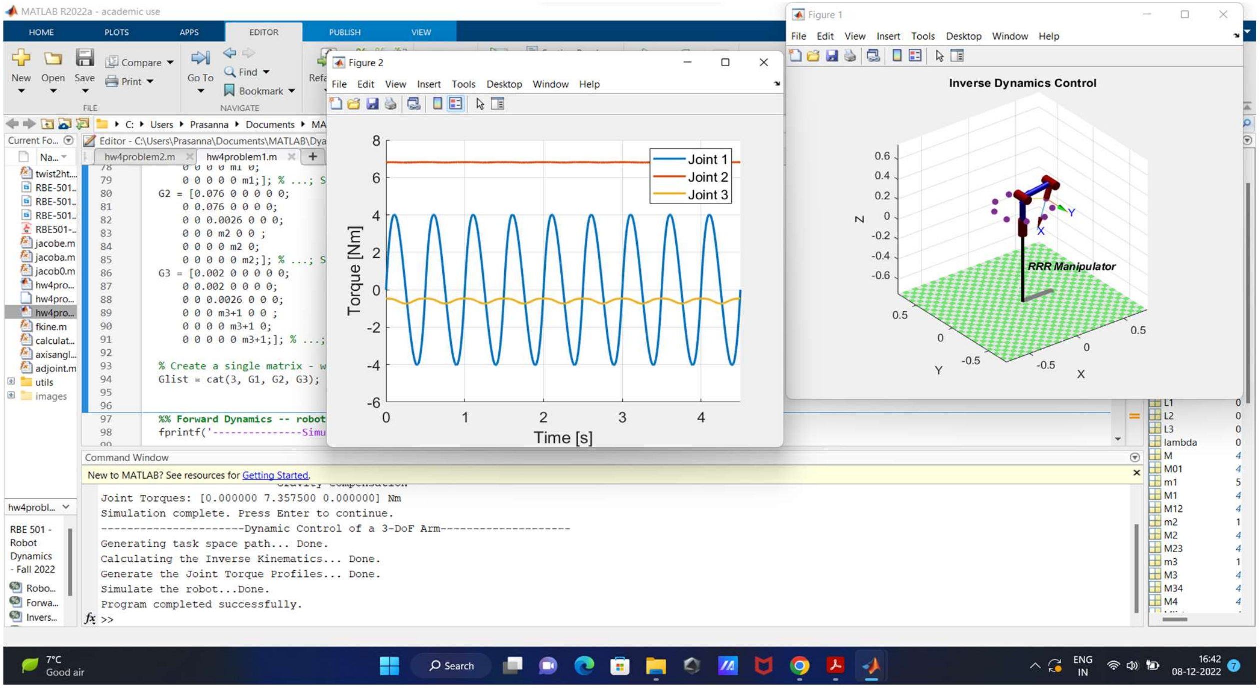
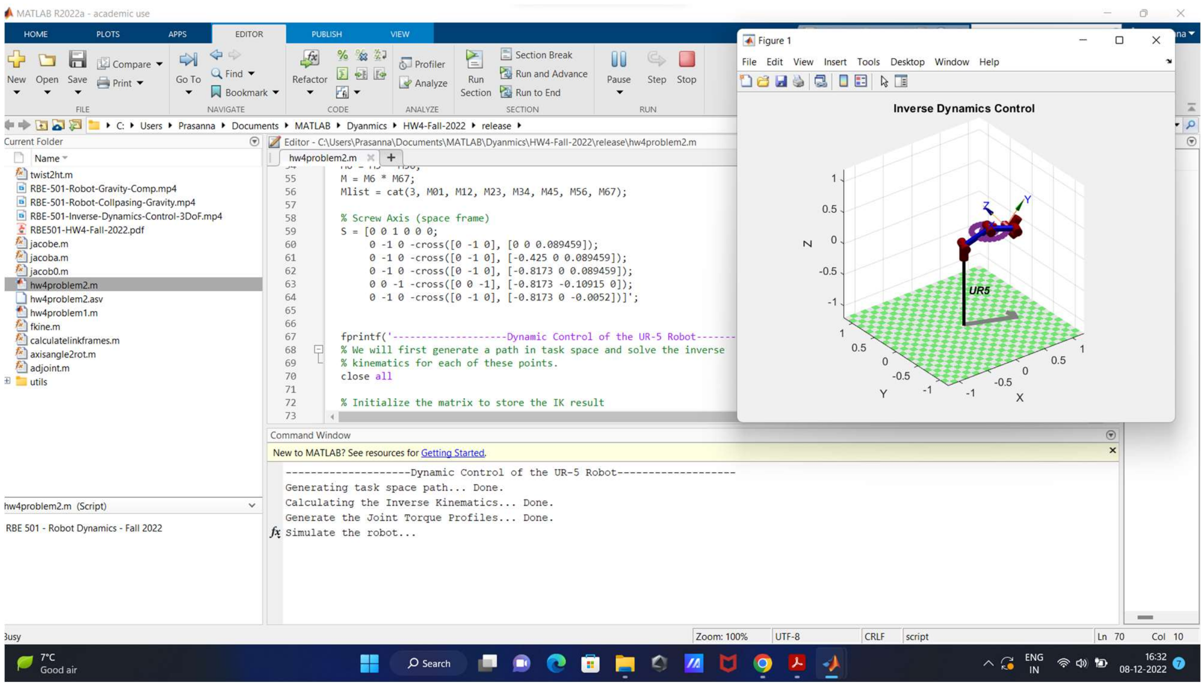


Figure 3: Results with added Payload (1 Kg) at the End Effector

The velocity for Joint 2 increases marginally, rest two Joints show similar velocities as before.

Problem 2:

In this question, the Spatial Inertia Matrices were provided. A tdh function was added which is used to calculate dh transformation matrices for the given joints. This function was required in the code to calculate link frames and home configurations of links with respect to the next link.



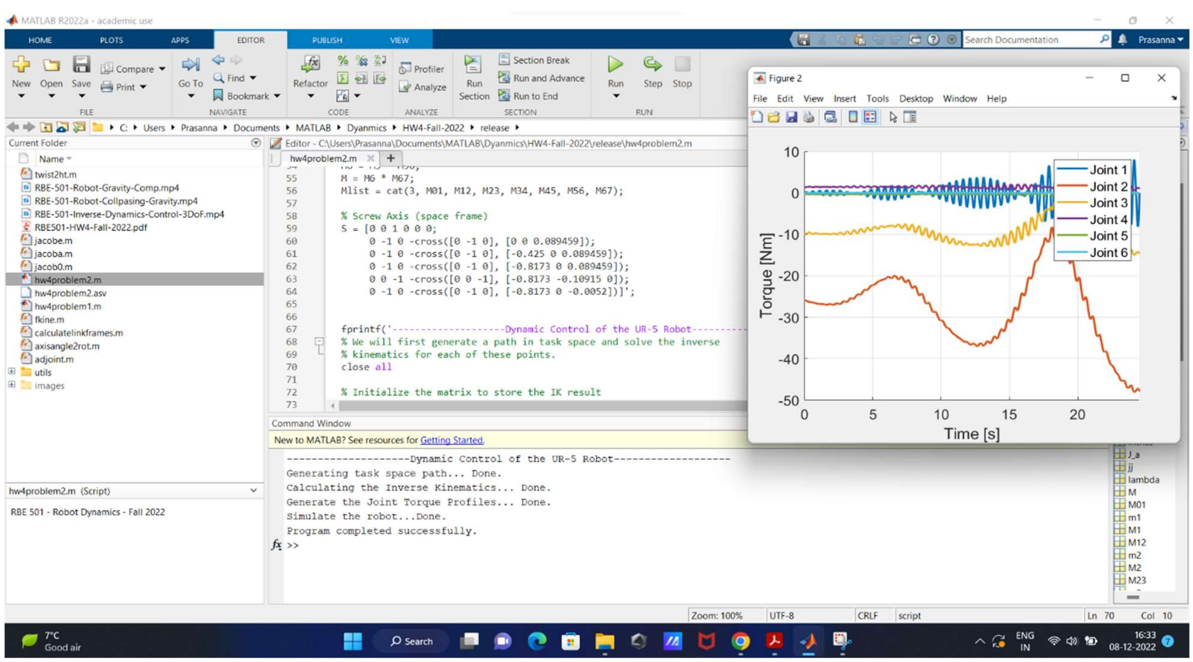


Figure 4 & 5: Results for UR-5 Robot