MTRN4230 Lab 09

1. Aim

This lab provides students with time to work on Project-2 as well as providing an attempt at determining the torque applied at each joint of a two link robotic arm.

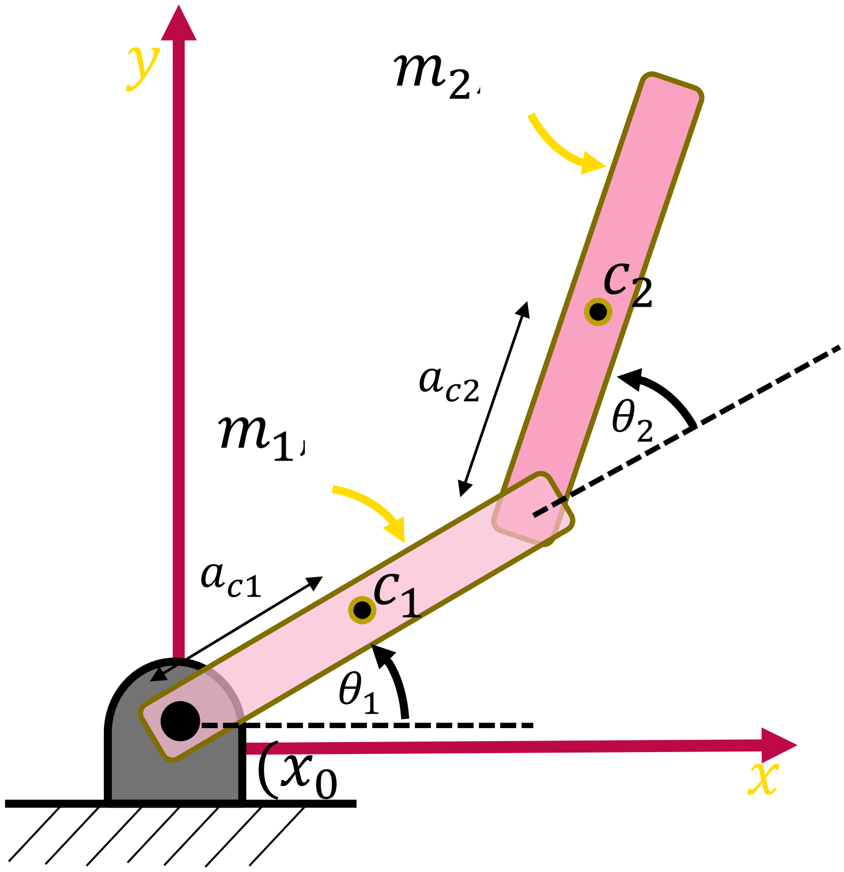
2. Pre-lab

Watch the lecture, to understand the equations required to solve Part A.

3. Lab Activities

Part A:

Consider a two-link robot as shown in this figure. The centre of mass of each link locates at their geometrical centre (a_{c1} = L1/2; a_{c2}=L2/2).



Assume that m1 = 4kg; m2 = 2kg; L1= 80cm; L3 = 60cm; width $_1$= width $_2$= 10cm; height of both links = 10cm. Assume that the links are rectangular prisms.

I. Use the RVC toolbox to calculate the Jacobian of the centre of mass of each link:

(i) Translational velocity Jacobian [J_{vo1} J_{vo2}]
(ii) Rotational velocity Jacobian [$J\omega_1$ $J\omega_2$]

II. Use the RVC toolbox to generate a trapezoidal trajectory for this robot to move from $(q1, q2)_{start}$ = (0, 0) to $(q1, q2)_{final}$ = (60, 90) in 6s (the blend time is t_b = 2s). What is the angular velocity and acceleration at t = 3s;

III. Calculate the torques applied to each joint at t = 3s, using the equation in the lecture. Note: The RVC toolbox uses a different approach (Recursive Newton-Euler algorithm) to calculate the dynamics equation; therefore, we do not apply this method in this lab.

Hints:

- Try to calculate the formula for (I) using matlab syms. Once the formula that you have matches with that presented on the lecture slides, sub in the parameters.
- For the calculation of the 0T1 and 0T2 matrix. Consider creating a one link and a two link robotic arm and calculating the fkine solution for both at the desired joint configurations.
- For (II) generating the trapezoidal trajectory, have a look at the 'trajectories.m' example code provided on moodle. For the mstraj function use '@lspb' instead of '@tpoly'

Part B:

Spend the remainder of the lab working on Project-2. The demonstrator will go through a summary of the task.

4. Post-lab:

- Further Resources:
  - https://www.youtube.com/watch?v=1U6y_68CjeY&ab_channel=NorthwesternRobotics
  - https://www.youtube.com/watch?v=BjD-pL819LA&ab_channel=NorthwesternRobotics
  - https://robotacademy.net.au/masterclass/robot-joint-control/?lesson=364
  - https://robotacademy.net.au/masterclass/rigid-body-dynamics/?lesson=391

List of equations:

$\sum_j d_{kj}(\boldsymbol{q})\ddot{q}_j + \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ijk}(\boldsymbol{q})\dot{q}_i\dot{q}_j + g_k(q) = \tau_k$

Inertia Matrix:

$$d_{11} = m_1 a_{c1}^2 + m_2(a_1^2 + a_{c2}^2 + 2a_1 a_{c2}\cos(q_2)) + I_1 + I_2$$

$$d_{12} = d_{21} = m_2(a_{c2}^2 + a_1 a_{c2}\cos(q_2)) + I_2$$

$$d_{22} = m_2 a_{c2}^2 + I_2$$

Coriolis and centripetal coupling matrix

$$c_{111} = \frac{1}{2}\frac{\partial d_{11}}{\partial q_1} = 0$$

$$c_{121} = c_{211} = \frac{1}{2}\frac{\partial d_{11}}{\partial q_2} = -m_2 a_1 a_{c2} \sin(q_2) = h$$

$$c_{221} = \frac{\partial d_{12}}{\partial q_2} - \frac{1}{2}\frac{\partial d_{22}}{\partial q_1} = h$$

$$c_{112} = \frac{\partial d_{21}}{\partial q_1} - \frac{1}{2}\frac{\partial d_{11}}{\partial q_2} = -h$$

$$c_{122} = c_{212} = \frac{1}{2}\frac{\partial d_{22}}{\partial q_1} = 0$$

$$c_{222} = \frac{1}{2}\frac{\partial d_{22}}{\partial q_2} = 0$$

Gravity Loading

$$g_1 = \frac{\partial P}{\partial q_1} = (m_1 a_{c1} + m_2 a_1) g cos(q_1) + m_2 a_{c2} g \cos(q_1 + q_2)$$

$$g_2 = \frac{\partial P}{\partial q_2} = m_2 a_{c2} g \cos(q_1 + q_2)$$