A - Calculations

1. Find the DH parameters for the 3-DOF RRR Puma.

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	q_1
2	0	L_1	0	q_2
3	0	L_2	0	q_3
4	0	L_3	0	q_4

2. Compute the gravity vector $G(q_1, q_2, q_3)$

$$G(q_1, q_2, q_3) = g \begin{bmatrix} r_1 \cos(q_1)\, m_1 + (L_1 \cos(q_1) + r_2 \sin(q_1 + q_2))m_2 + (L_1 \cos(q_1) + L_2 \sin(q_1 + q_2) + r_3 \sin(q_1 + q_2 + q_3))m_3 \\ r_2 \sin(q_1 + q_2)\, m_2 + (L_2 \sin(q_1 + q_2) + r_3 \sin(q_1 + q_2 + q_3))\, m_3 \\ r_3 \sin(q_1 + q_2 + q_3)\, m_3 \end{bmatrix}$$

B – Implementations

2. Tune the Controllers

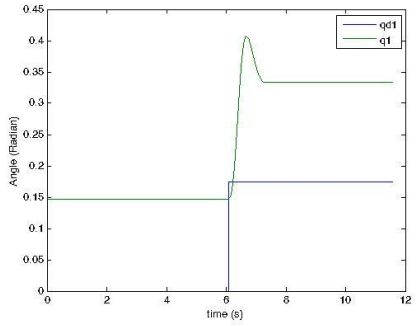
What kind of Behaviour do you observe with different gains?

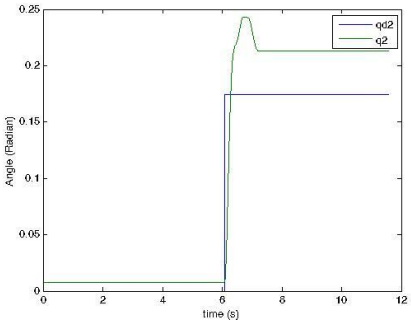
At low gains there is a high stationary error and the system is very slow. With the increase of the gain this stationary error decreases and the system gets to the destination much quicker, on the downside the system starts to overshoot and the torque that is being exerted by the joints increases greatly.

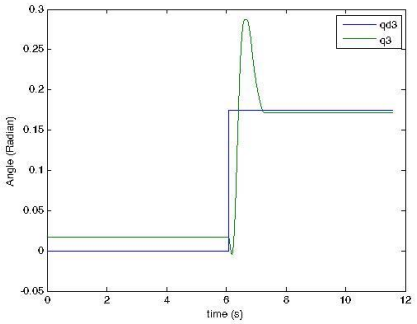
Why are well tuned gains different for each joint?

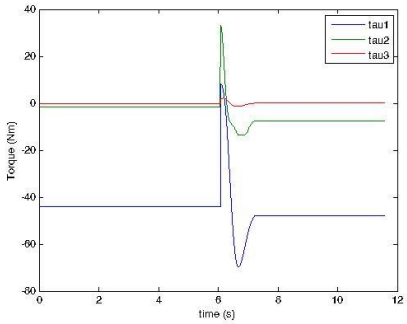
Each joint depends on different Links with different masses and the dynamics affecting each of them is completely different. We can observe in this iteration of the Puma robot with 3 degrees of freedom, that from the first until the third joint the controller has to be tuned with decreasing gains. We think that this behaviour is due to the centrifugal force being exerted on the outer joints, which makes them more likely to have a big overshoot.

3. Document Behavior

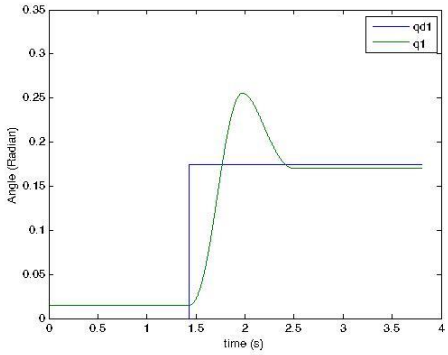


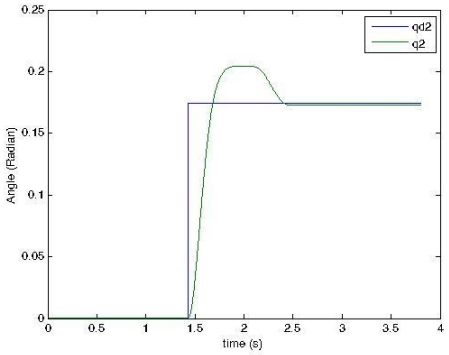


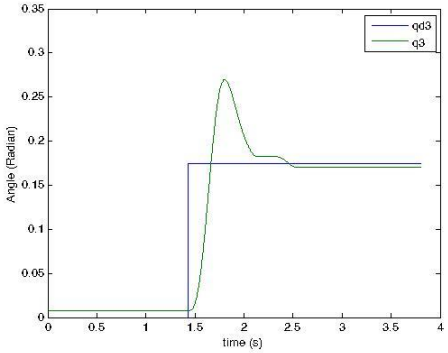


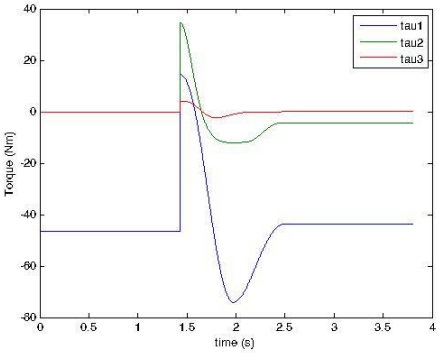


6. njgotocontrol()

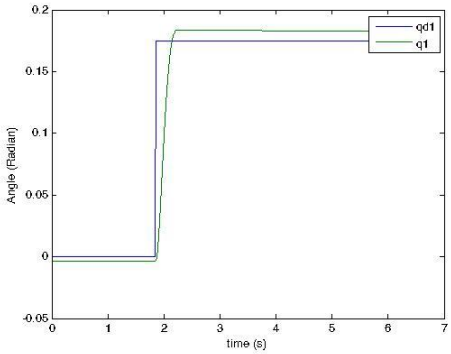


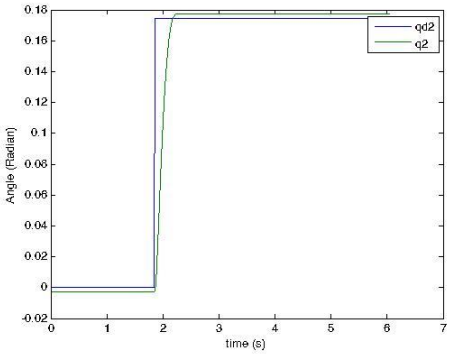


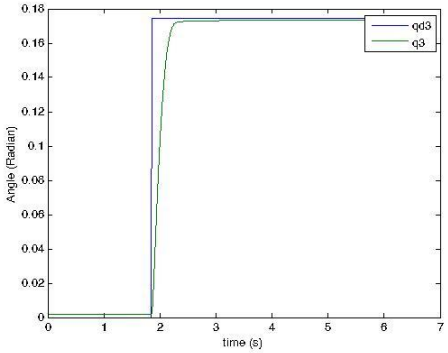


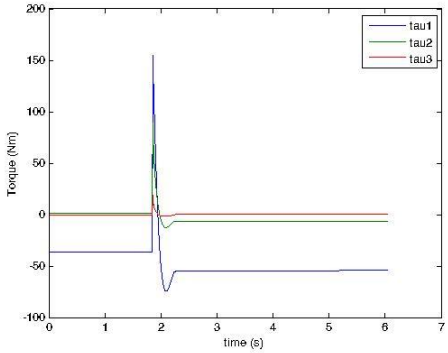


7. jgotocontrol()









Why can the gains Kp now be higher compared to the P-controller?

Because PD-controller applied both "proportional" control and "derivative" control, thus it has stronger control effect. In this assignment, the "derivative" control used force opposing velocity, which leads to dissipation. Therefore, 'P' control's gains can be higher and have stronger influence in compensation with 'D' control influence.

Student name	A1	A2	B1	B2	B3	B4	B5	B6	B7
Anupama Rajkumar	X	X	X	X	X	X	X	X	X
André Weigel	X	X	X	X	X	X	X	X	X
Weiheng Xia	X	X	X	X	X	X	X	X	X