Due: 12pm, 25th November, 2016

Dropbox #10 in JHE 307

1. A planar RRR robot has the manipulator Jacobian:

$$J(q)=\begin{bmatrix} -a_1S\theta_1 - a_2S\theta_{12} - a_3S\theta_{123} & -a_2S\theta_{12} - a_3S\theta_{123} & -a_3S\theta_{123} \\ a_1C\theta_1 + a_2C\theta_{12} + a_3C\theta_{123} & a_2C\theta_{12} + a_3C\theta_{123} & a_3C\theta_{123} \\ 1 & 1 & 1 \end{bmatrix}$$

and the vector of gravity terms (gravity acts in the $-Y_0$ direction):

$$G(q)=\begin{bmatrix} (\tfrac{1}{2}m_1 + m_2 + m_3)ga_1C\theta_1 + (\tfrac{1}{2}m_2 + m_3)ga_2C\theta_{12} + \tfrac{1}{2}m_3ga_3C\theta_{123} \\ (\tfrac{1}{2}m_2 + m_3)ga_2C\theta_{12} + \tfrac{1}{2}m_3ga_3C\theta_{123} \\ \tfrac{1}{2}m_3ga_3C\theta_{123} \end{bmatrix}$$

The link lengths and masses are: a_1=0.5 m , a_2=0.5 m, a_3= 0.1 m, m_1=10 kg, m_2=10 kg and m_3=2 kg.

(a) If the arm is holding a 5 kg payload, when $\theta_1 = 45°, \theta_2 = -75°$ and $\theta_3 = 30°$, calculate the required joint torques.

(b) The robot's control unit can only control the torques with a resolution of 0.1 Nm. We are interested in using the robot to apply a precise force in the X_0 direction (*e.g.* to insert a component without damaging it). We can use configuration A: $\theta_1 = 45°, \theta_2 = -75°$ and $\theta_3 = 30°$, or configuration B: $\theta_1 = 45°, \theta_2 = -5°$ and $\theta_3 = -40°$. Note that both configurations align the tool with X_0 (*i.e.* $\phi = 0$). Determine which configuration will provide the most precise force output.