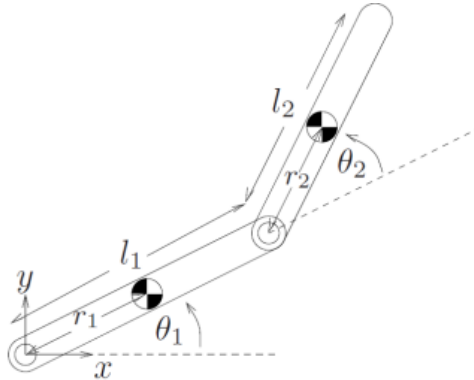# Homework 6

(Due time: 10:00, May. 17, 2024)

1. For the two-link planar manipulator shown below.

Model each link as a homogenous rectangular bar with mass $m_1 = m_2 = 12\text{Kg}$, length $l_1 = l_2 = 1.0\text{m}$, $r_1 = r_2 = 0.5\text{m}$ and moment of inertia tensor

$$I_1 = I_2 = \begin{bmatrix} 0.0125 & 0 & 0 \\ 0 & 1.0025 & 0 \\ 0 & 0 & 1.01 \end{bmatrix}$$

relative to a frame attached at the center of mass of the link and aligned with the principle axes of the bar.

(a) Derive the dynamic equations of the manipulator (using Lagrange's Equations)

(b) Derive the dynamic equations of the manipulator (using computation algorithm of Dynamics of Open-chain Manipulators with the Christoffel Symbol)

(c) Do the position control simulation in joint space of the manipulator with Matlab&Simulink to move the arm along the trajectory of Problem 1&2 in HW5, while the maximum joint torque $\tau_{1max} = \tau_{2max} = 20\text{N/m}$, with the controllers the following three controller. Try to obtain the best performance of the tracking problem, provide the chosen control parameters, K_p and K_v. The torque, position, velocity history graphs are required. Try to compute position error history for both joint angles. Discuss the relationship between the joint position error and the control parameters.

i) Computed torque control.

ii) PD control

iii) Augmented PD control