Final Exam, 12/8/2020

Robot Dynamics

Due Friday, 12/11/2020 @11:59 PM

Problem 1

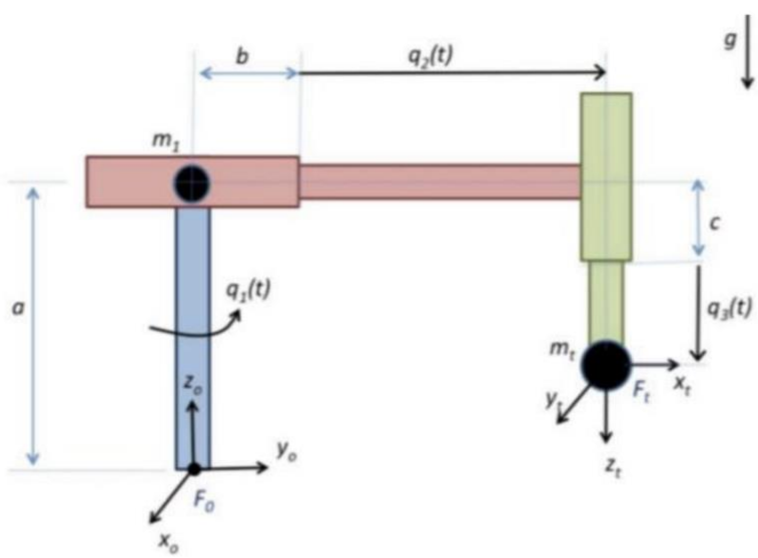
Consider the three-DOF arm in the figure below. Consider the links to be massless, that is, consider only the point masses labeled m_1 and m_t below.

a) Derive the dynamical model of the robot using Lagrange's approach and put it in the form of $\boldsymbol{\tau} = M(\boldsymbol{q})\ddot{\boldsymbol{q}} + C(\boldsymbol{q},\dot{\boldsymbol{q}})\dot{\boldsymbol{q}} + g(\boldsymbol{q})$. **(30 points)**

b) Derive the dynamical model using Newton's approach and put it in the form of $\boldsymbol{\tau} = M(\boldsymbol{q})\ddot{\boldsymbol{q}} + C(\boldsymbol{q},\dot{\boldsymbol{q}})\dot{\boldsymbol{q}} + g(\boldsymbol{q})$. **(30 points)**

c) Consider the following physical parameters for the robot: $a = 0.3\,m$, $b = c = 0.1\,m$, $m_1 = m_2 = 0.5\,kg$, $g = 9.8$. Substitute these parameters in the models derived in parts a and b and compare the results. **(10 points)**

d) Plan a trajectory such that the end-effector starts at $t = 0s$ with the initial position of $x_{ti} = (0, 200, 150)\,mm$ with zero velocity, and <u>while following a straight line</u>, ends at $t = 10s$ with the final position of $x_{tf} = (200, 0, 200)\,mm$ with zero velocity. Plot the time-position, time-velocity, and time-acceleration trajectory graphs for all the joints from $t = 0$ to $t = 10$ seconds (joint space). Also, plot the resultant end-effector path/trajectory using the forward kinematics i.e. track the position of the end-effector (x-y-z) as a result of your solution (task space) within the motion. Show both your solution and the desired trajectory together in a single graph (3D) for comparison. **(30 points)**



Good Luck!