University of Maryland – College Park
A. James Clark School of Engineering
ENPM662- Fall 2021 **Due date: December 17, 11:00 pm**

Pick and place using a humanoid robot (20 points):

Design a humanoid robot with a total of 15 DOFs (including 1 DOF for the head) that is capable of walking and at the same time can carry a cubic object, 20 lbs, using both hands as follows:

a. Sketch robot design with rough dimensions and show different DOFs **(2 points)**

b. Estimate mass of each link and the total mass of the robot. (Link Material: Aluminum; Each motor weights: 1 lb) **(1 point)**

c. Calculate the inverse and forward kinematics for the robot. Note that the robot should be able to lean forward or perform squat depending on the height of the object's location to reach it and grab the object with two arms. **(5 points)**

d. Using the dynamic equations find out the max torque required for each motor (only for the arm joints) such that the motor provides enough torque to compensate for the gravitational force related to both robot and the object throughout the entire workspace. **(4 points)**

e. Design a pick and place scenario and find out the joint positions and torques in two modes and plot them. 1) Reaching mode **(4 points)**, 2) grasping and handling mode **(4 points)**.

Notes:

1. Consider the frictional metal to cardboard contact between the robot's hand and the object.
2. The robot can be assumed to have reached near the place where the object is kept on a table which is at a height of its knees. So, the robot must bend forward OR perform squat in order to be able to pick up that object.

3. You don't have to consider the legs in the dynamic equations. Also, since the object will be picked using both the hands, it will create a close loop scenario which is out of scope of this subject, so you can assume that only one hand is picking up an object half of the weight (10 lbs) and formulate the dynamic equations.

4. For the dynamic equations, all the joints can be assumed quasi static (q_dot and q_double_dot will be zero at all times. Although, q_dot cannot be taken as zero in the IK equations).