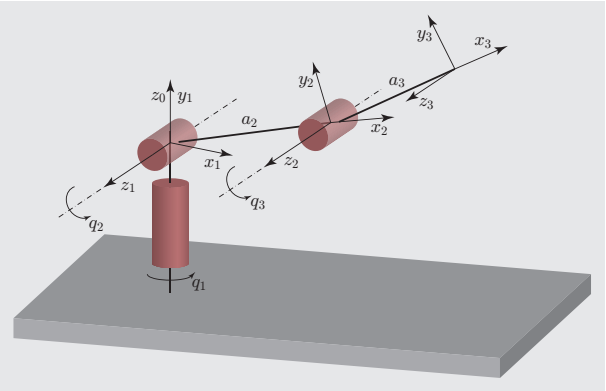
FOUNDATIONS OF ROBOTICS
(Prof. Bruno SICILIANO: Academic Year 2025–2026)

Master's Course in Automation Engineering and Robotics

TECHNICAL PROJECT

Student(s): _____

Consider the anthropomorphic arm in the figure



with the following DH parameters: $a_2 = a_3 = 0.5\,\text{m}$. Each link is assumed of cylindrical form with radius $r = 0.1\,\text{m}$ and uniformly distributed mass $m = 5\,\text{kg}$. Each motor is characterized by $I_m = 0.0004\,[\text{kg}\cdot\text{m}^2]$ and $B_m = 0.0001\,[\text{N}\cdot\text{m}\cdot\text{s/rad}]$ with a gear ratio $n_r = 100$.

- Analyze velocity and force manipulability plotting the relative ellipsoids for a significant number of positions of the end-effector within the workspace.
- Plan the trajectory along a path characterized by at least 11 points within the workspace, in which there are at least one straight portion and one circular portion and also the passage for at least 2 via points.
- Implement the CLIK algorithms in MATLAB with both Jacobian inverse and transpose along the trajectory. Adopt Euler numerical integration rule with sampling period of 1 ms.
- Assuming to relax a task space component, implement the CLIK algorithm in MATLAB with Jacobian pseudo-inverse along the trajectory when optimizing a dexterity constraint.
- Consider a concentrated end-effector payload of about 1 kg. Then, design: 1) an adaptive control; 2) a robust control; 3) a task space inverse dynamics control with the adoption of an integral action to recover the steady-state error due to the uncompensated load. Simulate in MATLAB the motion of the controlled manipulator under the assumption that the desired joint trajectories for the first two controllers are generated with a 2nd-order CLIK algorithm. Implement discrete-time controllers with a sampling period of 1 ms.