MCE/EEC 647/747
Midterm Exam
Take-Home Portion
40 points

A PUMA robotic manipulator fitted with a laser beam will be used in the lab to measure world coordinates. Only the first three joints will be used. Figure 1 shows a plan view and a frontal view of the robot, along with coordinate frames according to the DH convention. Table 1 lists all relevant dimensional pa-

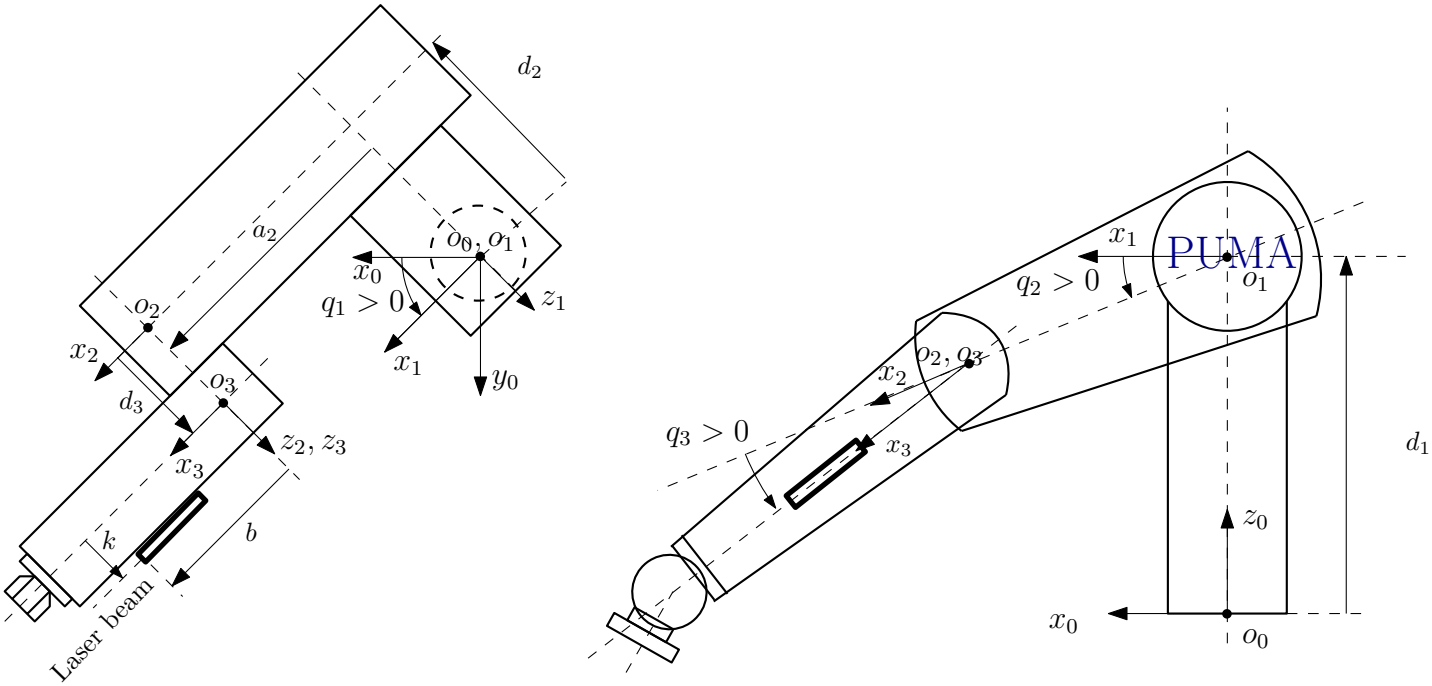

Figure 1: PUMA robot and frames

rameters, some measured directly, some from Corke and Armstrong [1]. A manual control system has

Length	Value (mm)
d_1	666
d_2	243.5
a_2	431.8
d_3	93.4
b	270
k	52.1

Table 1: PUMA length parameters

been prepared that allows precise pointing with the laser beam. The three joint angles corresponding to any desired beam direction are the only data that will be collected. That is:

- The distances between the light source and the chosen target points are not known, and direct measurement is not to be attempted.

- Nothing can be assumed about the relative orientations and distances between the world coordinate system and lab objects (walls, tables, etc).

A very accurate square has been drawn on a flat surface. Only the length of the sides will be known. As many points as necessary will be collected by pointing the laser at the square and reading the corresponding robot joint angles.

- This may be a group activity, with up to 3 students per group. Different solutions are expected from each group.
- What is the minimum number of points to be taken along the square's perimeter to determine their world coordinates, the equation of the plane and the distances between the points and the light source?
- In the lab, more points than the minimum will be taken. Carefully describe a sequence of calculations to be used to find the required information from the collected data.

This portion of the exam is due on March 7th (one oral presentation per group). Group members will be asked to give a 5-minute presentation explaining their solution approach.

1. Each group will be allowed 30 minutes for data collection in the lab. Office hours on March 6 and March 7 will be used.
2. A separate lab guide will be provided.

References

[1] Corke, P.I. and Armstrong-Hélouvry, B. *A search for consensus among model parameters reported for the PUMA 560 robot*, Proc. IEEE 1994 Intl. Conf. Robotics and Automation, San Diego, California.