University of Tehran
College of Engineering
School of Electrical and Computer
Engineering (ECE)
School of Mechanical Engineering
(ME)

Mechatronics & Robotics

Homework 2:
Kinematic Modeling of Robotic Arms

Teaching Assistants:

Navid Razaghi
Parsa Namazian

Deadline: 8 April 2024 (20 Farvardin), 23:59

List of Problems

Problem 1: Wrist Robot (20 points)

Consider the following 6-degree-of-freedom robot.The third joint is a prismatic joint.

- Find D-H parameters for this robot.

- According to the above part, find Q_i and $\overrightarrow{a_i}$.

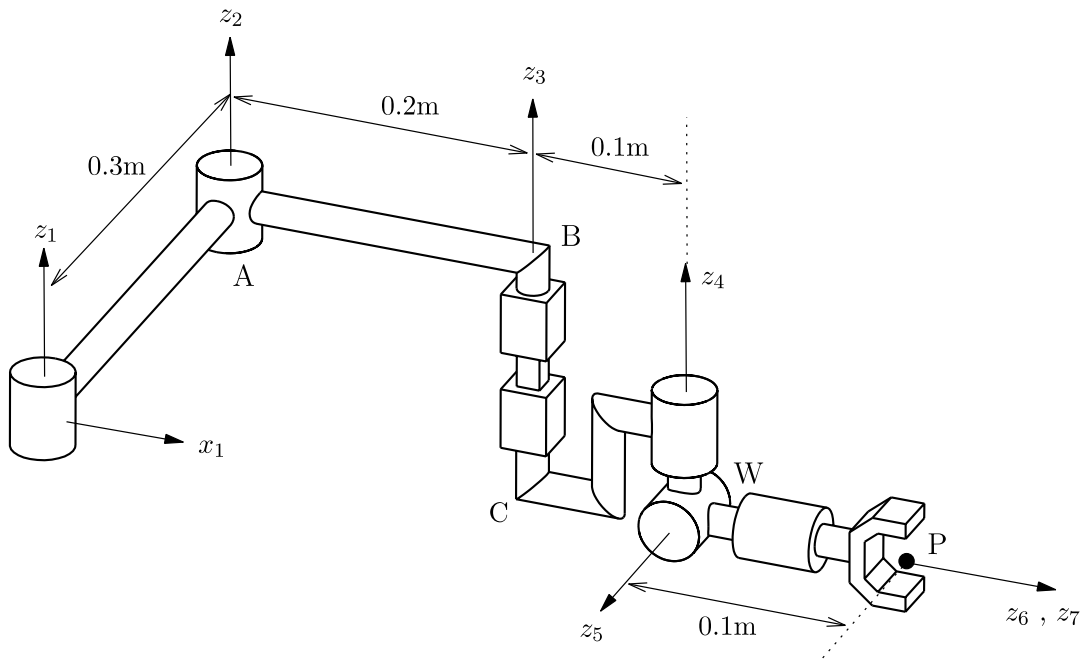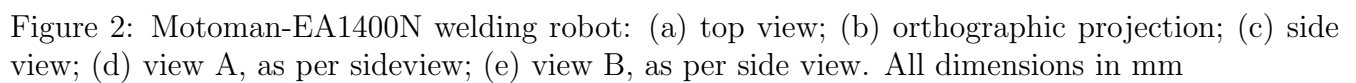- $P_W = \begin{bmatrix} x_w \\ y_w \\ z_w \end{bmatrix}$ is wrist point of the robot.Calculate it.

Figure 1: 6-DOF robot

Problem 2: Motoman-EA1400N Welding Robot (20 points)

The following figure is the data sheet of the Motoman-EA1400N welding robot.

- Under the assumption that the operation point of the robot is located along the axis of the 6th joint, on the flange indicated in view A, produce a table with Denavit-Hartenberg parameters of the robot.

- Is this robot decoupled?

- Form the FKP for this manipulator.

N.B.: All lengths are indicated in mm.It is strongly recommended to sketch the robot at an arbitrary posture in order to ease the definition of the DH coordinate frames.

Figure 2: Motoman-EA1400N welding robot: (a) top view; (b) orthographic projection; (c) side view; (d) view A, as per sideview; (e) view B, as per side view. All dimensions in mm

Problem 3: FANUC S-420i (20 points)

The data sheet of FANUC robot known as S-420i is attached.

- According to the datasheet, form the DH parameters and solve the FKP.

- Is this robot decoupled? Solve the IKP for this manipulator. Find the number of answers to the IKP.

- Solve the FKP and IKP using MATLAB's Robotics Toolbox and verify your answers in the previous item. To verify them, given a sine wave profile to the actuators, solve the FKP using the equations and toolbox. The answers must be the same. Do it vice versa for the IKP.

S-420i S
Top
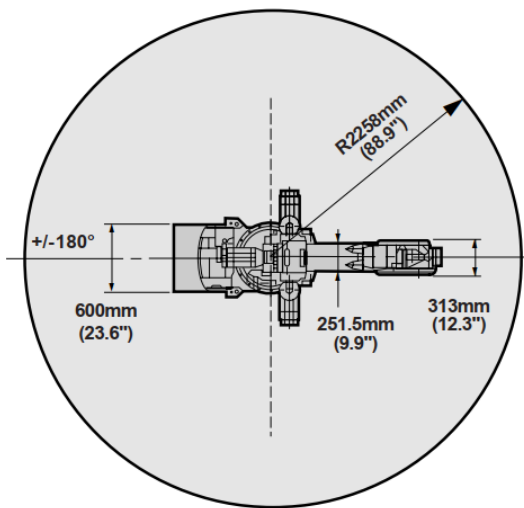
Top view
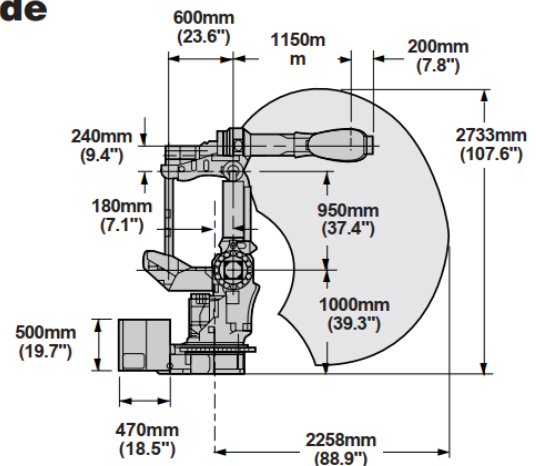
Side view

Figure 3: S420-i

Problem 4: IKP (20 points)

Consider the following three-degree-of-freedom robot, where all axes of rotation are at an angle of 90 degrees.

- Find the table of D-H parameters by drawing the axes corresponding to each joint.

- According to the previous part, find the $\overrightarrow{a_i}$ vectors and Q_i matrices related to each link.

- According to the previous part, obtain the forward kinematics problem.

- According to the above part, solve the inverse kinematics problem for θ_1 and θ_3 by referring to the two equations that are solved to obtain the value of these joints. (It means two equations in which there is no θ_2 term and it is possible to calculate the indicated values by forming a system of equations)
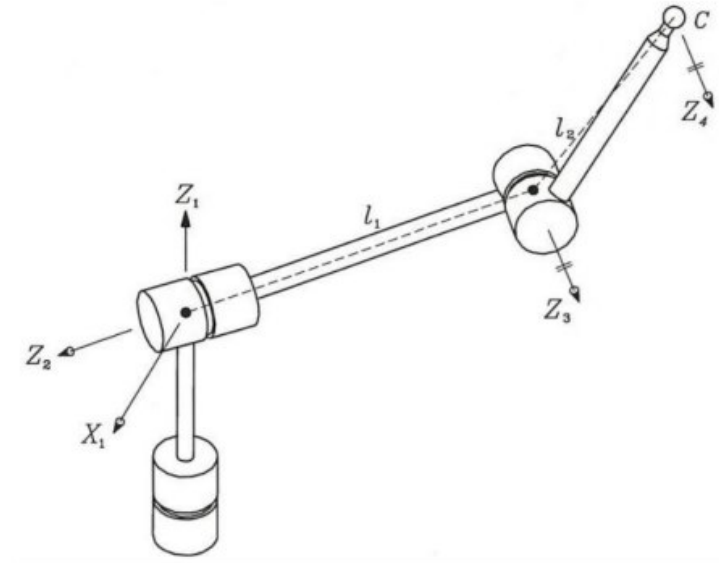

Figure 4: 3-DOF Robot

Homework Guidelines and Instructions

- The deadline for sending this exercise will be until the end of Monday, April 8th.

- This time cannot be extended and you can use time grace if needed.

- The implementation must be in Python programming language and your codes must be executable and uploaded along with the report.

- This exercise is done by one person.

- If any similarity is observed in the work report or implementation codes, this will be considered as fraud for the parties.

- Using ready-made codes without mentioning the source and without changing them will constitute cheating and your practice score will be considered zero.

- If you do not follow the format of the work report, you will not be awarded the grade of the report.

- Handwritten exercise delivery is not acceptable.

- All pictures and tables used in the work report must have captions and numbers.

- A large part of your grade is related to the work report and problem solving process.

- Please upload the report, code file and other required attachments in the following format in the system: `HW1_[Lastname]_[StudentNumber].zip`
  For example, the: `HW1_Ezati_12345678.zip`

- If you have questions or doubts, you can contact the assistants through the following e-mail with the subject HW2-Mechatronics. Stay in touch educationally:

  - `Navid.Razaghi@ut.ac.ir` (Navid Razaghi)
  - `PNamazian@ut.ac.ir` (Parsa Namazian)

- Be happy and healthy