

Exercise1: Consider a simple anthropomorphic arm in Fig.1. Several practical uses of this arm can be seen in [1](#) and [2](#).

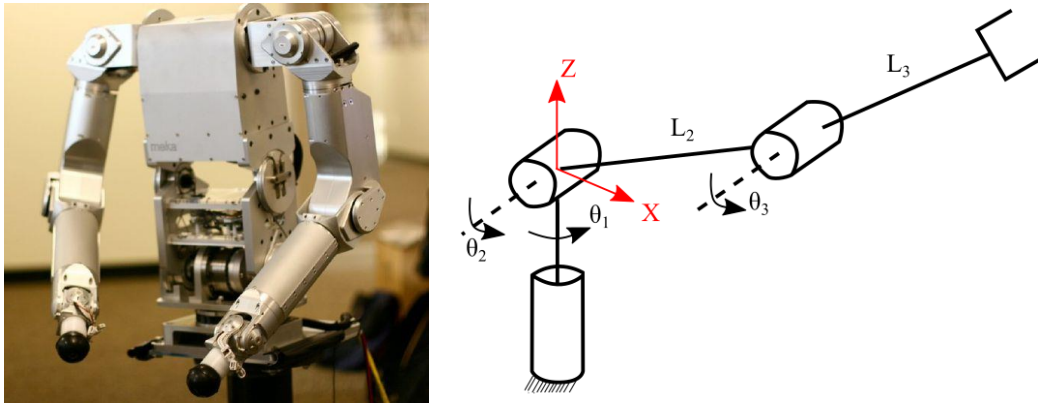
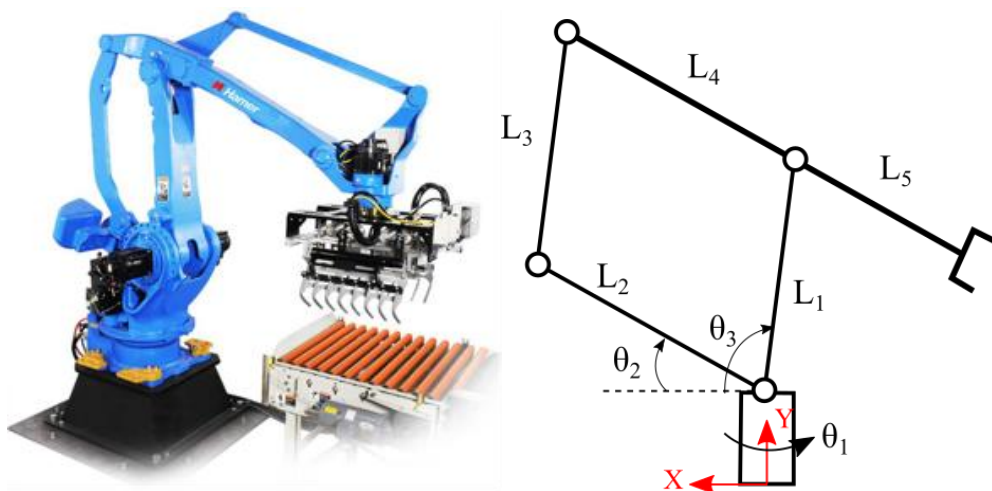


Fig1. Kinematic Structure of the simple anthropomorphic arm

1. Derive explicit dynamics model of the robot.
2. **Extra Point:** Derive linear regression form of robot dynamics¹. Verify your answer with an explicit dynamic model.

$${}^i I_{G_i} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & I_{yy} & 0 \\ 0 & 0 & I_{zz} \end{bmatrix}, \text{CG of each Link: Center of each Link}$$

Exercise2: Palletizing is a demanding application of stacking boxes, bags, cases, bottles, and cartons onto pallets as the last step in the assembly line before being loaded onto a shipping truck. A schematic of a 3-DOF [palletizer robot](#) can be seen in Fig 2.



¹ **Hint:** References [1](#) and [2](#) (section 3.3 and appendix A) can be helpful.

Fig2. Kinematic Structure of 3-DOF palletizer robot

1. Derive explicit dynamics model of the robot.

$${}^i I_{G_i} = \begin{bmatrix} I_{xx} & 0 & 0 \\ 0 & I_{yy} & 0 \\ 0 & 0 & I_{zz} \end{bmatrix}, \text{CG of each Link: Center of each Link}$$

Project: Consider 3-DOF parallelogram-based robot in Fig.1. Such kinematic structure has been used in many surgical robots such as [Da Vinci](#) and [PRECEYES](#).

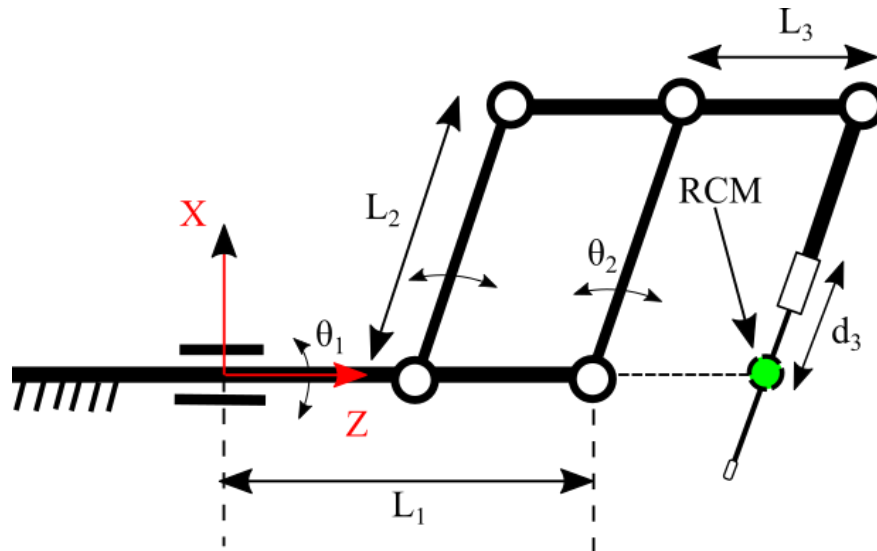


Fig1. Kinematic Structure of 3-DOF parallelogram-based robot. To better understand the above schematic, see this [link](#).

1. Derive explicit dynamics model of the robot.
2. **Extra point:** Verify the dynamic model with a commercial program². Teamwork is recommended.

$${}^i I_{G_i} = \begin{bmatrix} I_{xx} & 0 & 0 \\ 0 & I_{yy} & 0 \\ 0 & 0 & I_{zz} \end{bmatrix}, \text{CG of each Link: Center of Link}$$

Code language: It's recommended to use MATLAB to develop your codes. But you can use other symbolic software such as Maple or Mathematica.

How to contact teaching assistants: If you have any questions about these exercises, please contact us through [Email](#).

How to submit: Zip your files (codes, reports, etc.) within the format of HW#_Name_StudentID, and submit them to the LMS website.

Late homework policy: Please submit your assignments on time. If you run out of time, you can still send it as late submission only by one day with the expense of losing some marks depending on the time you submit your work.

² The use of MATLAB SimScape Multibody is recommended [[1](#), [2](#), [3](#), [4](#)].

Collaboration policy: Collaboration with humans is very beneficial but restricted to the “whiteboard level,” meaning that we recommend you to discuss approaches and solutions with your peers, but write your code, reports, and analytical derivations by yourself.

Appendix

Please use the kinematic solutions considered in the previous answers to calculate the Jacobian matrices of each link.