

## Introduction to Robotics

Manipulation and Programming

Unit 2: Kinematics

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### Objective

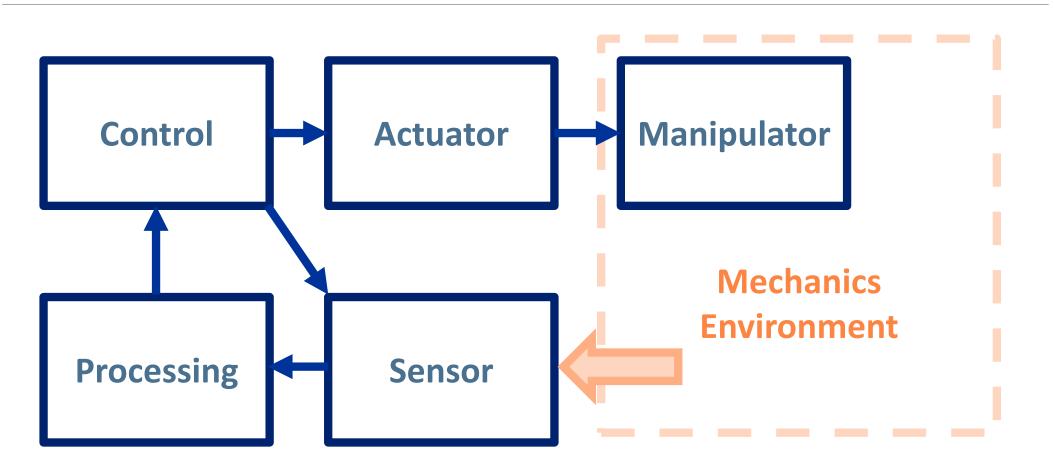
- Learn what is Robot model
- Learn how to draw KD (Kinematics Diagram)

# Robot Model

SECTION 1



## **Robots Computing Model**





### Robot Arm is a Manipulator

- A robot arm receive control signals from an actuator which can be a
  - Remote Control,
  - Cell Phone,
  - PC, or
  - Mouse
- A Robot Arm is manipulated to perform a certain task.

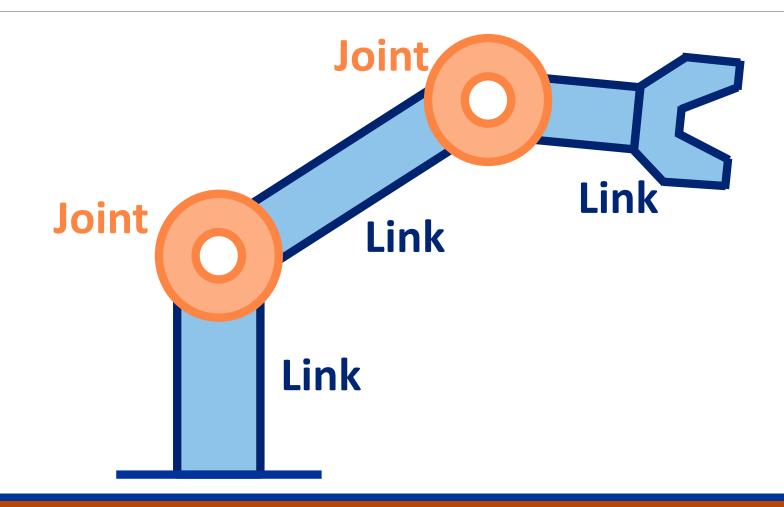


# Kinematics Diagram

SECTION 2



#### Robot Arm consists of Joints and Links





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**Prismatic Joint** 





Link

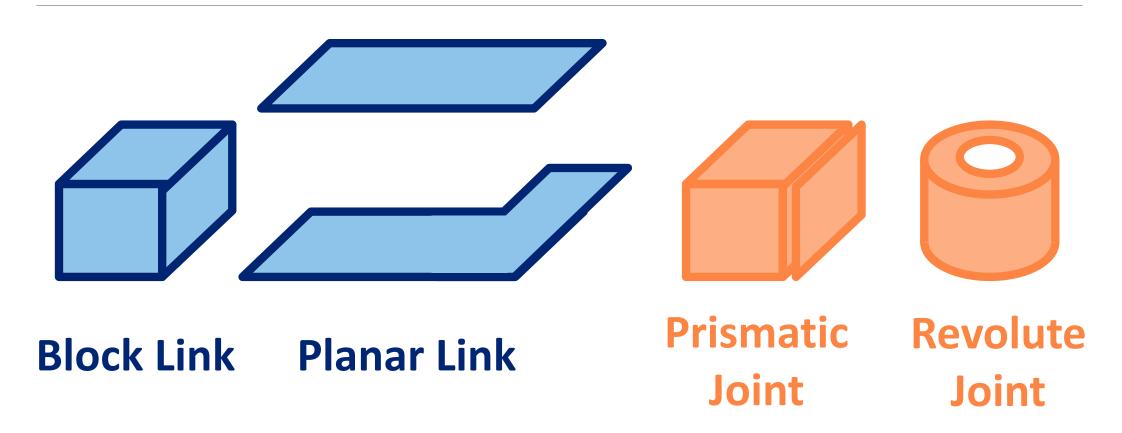


## Kinematics Diagram

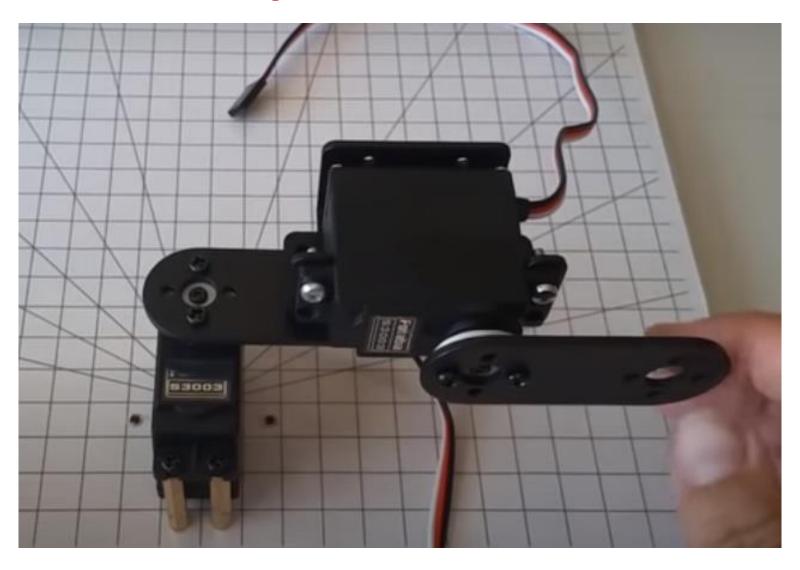
- •2 D Model
- •3 D Model



### 3D Model

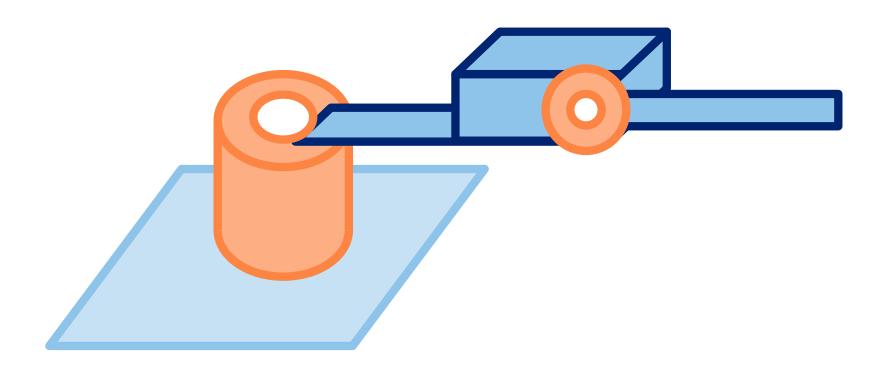


# **Example Robot Arm 1**



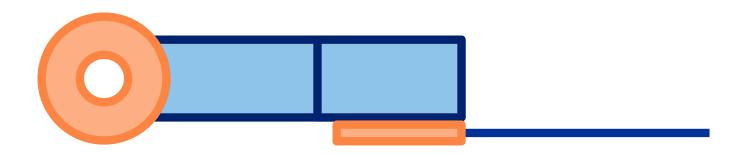


# Kinematics Diagram (3D)



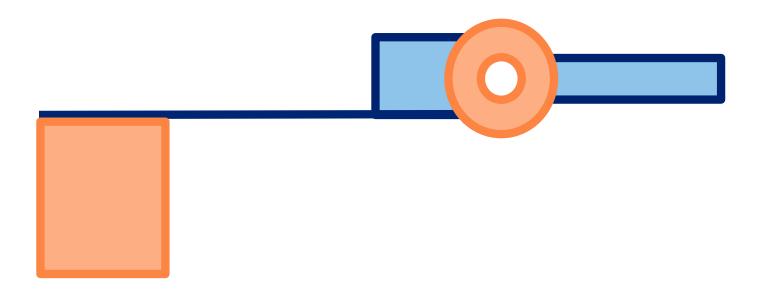


## Kinematics Diagram (2D Top View)





## Kinematics Diagram (2D From View)

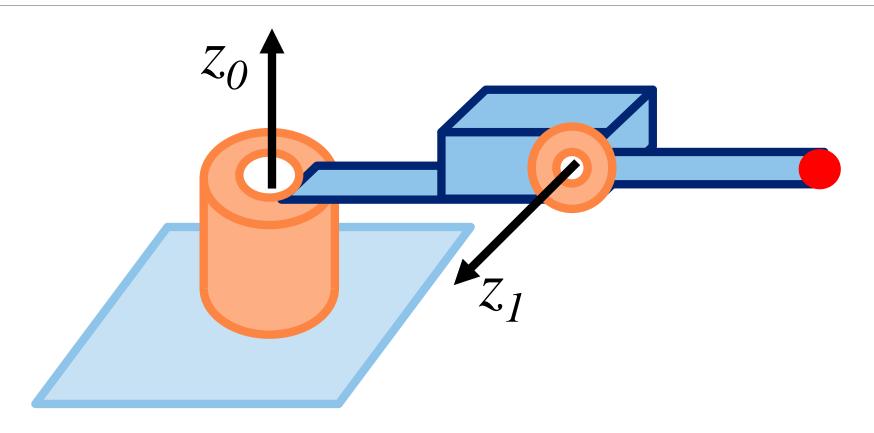


# Kinematics Diagram

SECTION 3 ASSIGNMENT OF AXIS



# Kinematics Diagram (3D) Joint (Z)

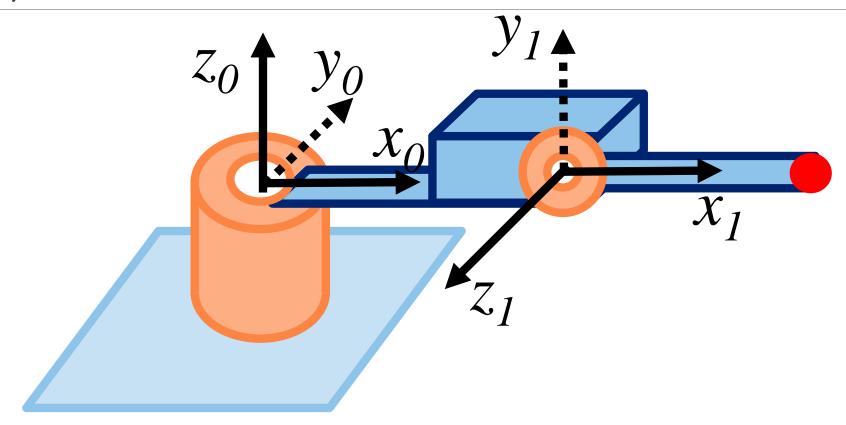








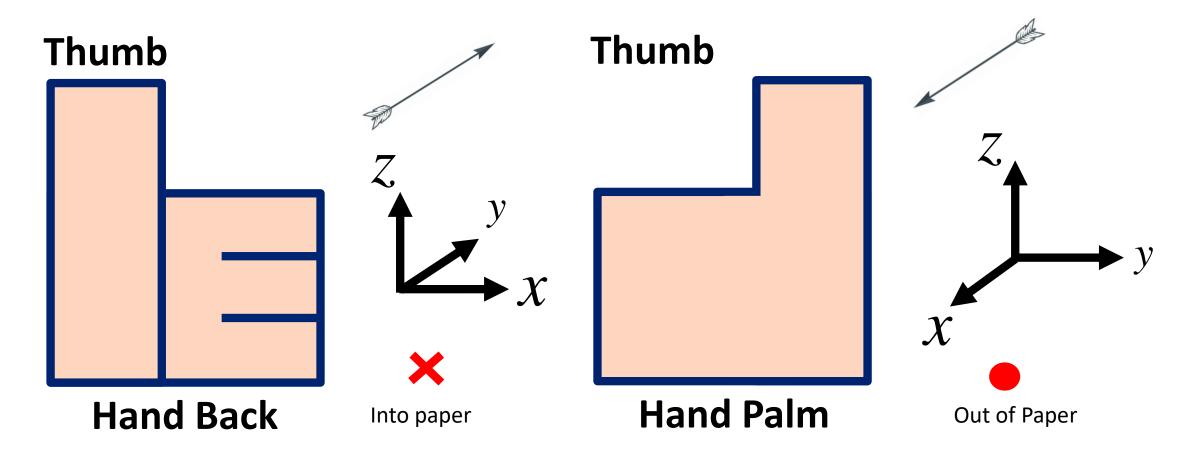
# Kinematics Diagram (3D) Joint(x)





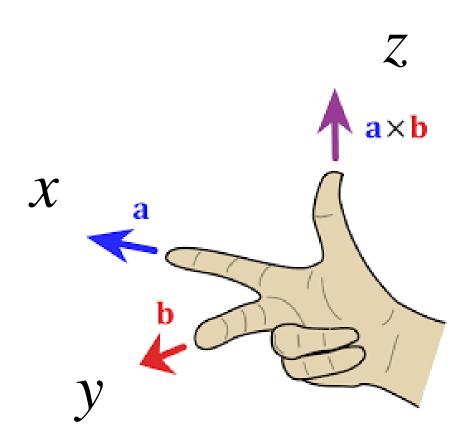


## Right Hand Rule





## Right Hand Rule







#### Rule # 1:

•The Z-Axis must be the axis of rotation for a revolute join, or the direction of motion for a prismatic joint.



#### Rule # 2:

- •The X-axis:
  - The X-axis must be perpendicular both to its own z-axis, and the z-axis of the frame before it.



#### Rule # 3:

•All frames must follow the right-hand rule. (Cross-product)



#### Rule # 4:

•Each X-axis must intersect the Z-axis of the frame before it.

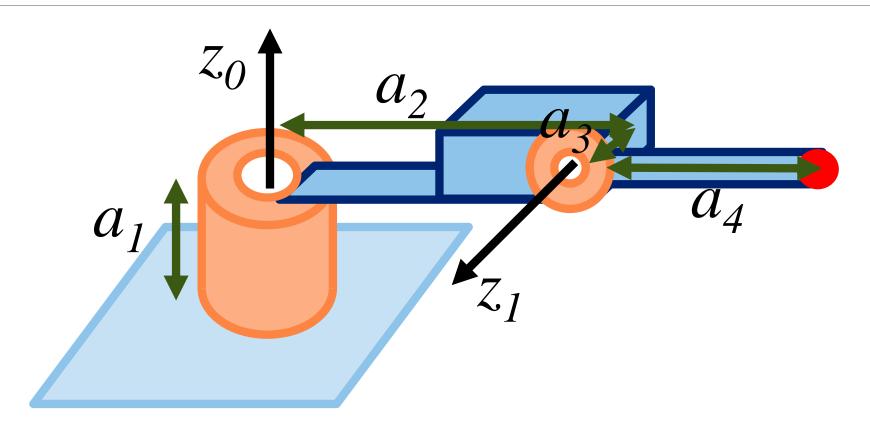
# Kinematics Diagram

SECTION 3 PARAMETERS AND VARIABLES



## Kinematics Diagram (3D)

Parameters (a: distance from the previous joint)



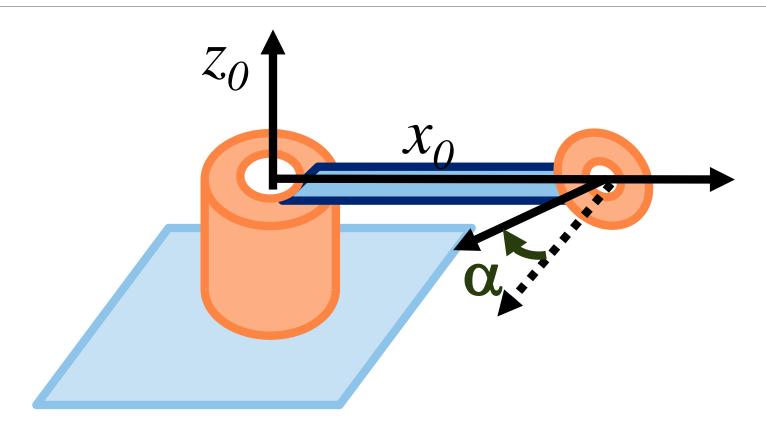






### Kinematics Diagram (3D)

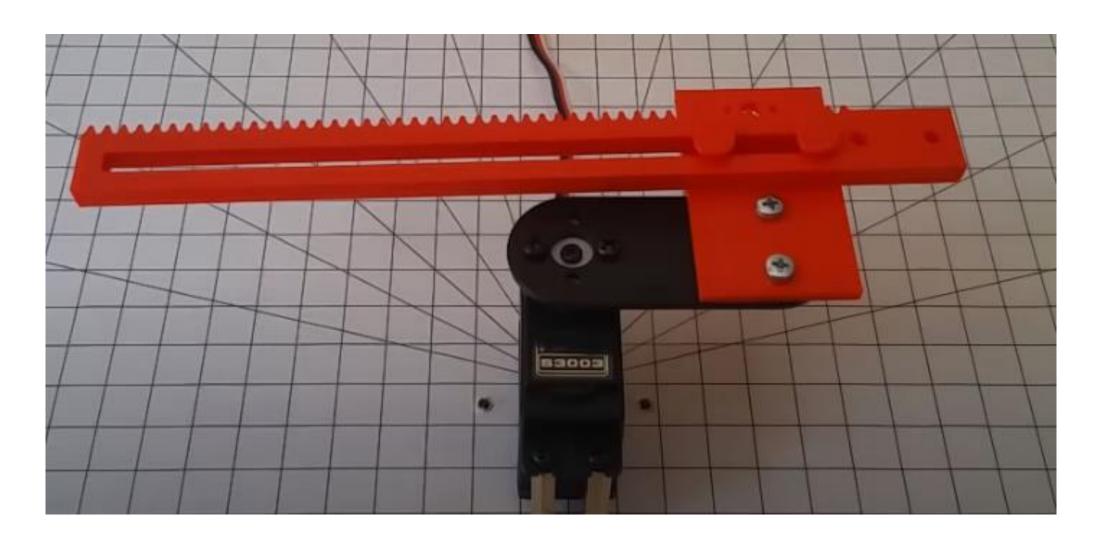
Parameters ( $\alpha$ : angle of a z joint to previous x axis)







## **Example Robot Arm 2**



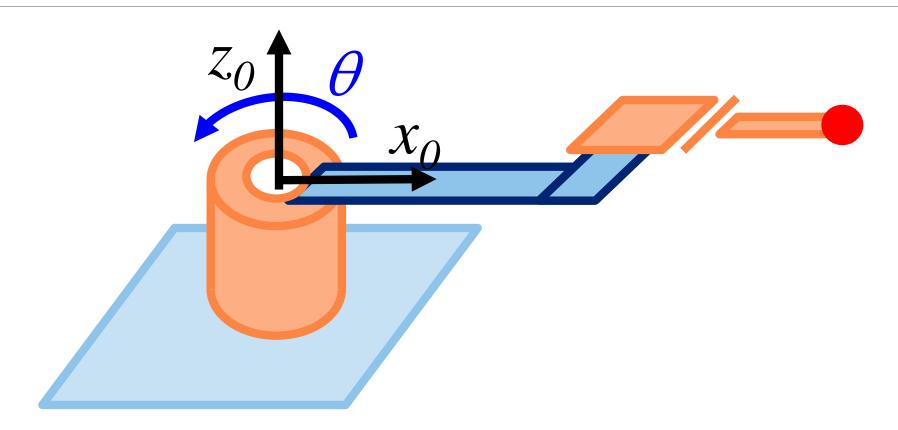


#### Joint Variable

•The value that changes when a joint moves.



## Kinematics Diagram (3D) Joint Variables - angle $\theta$

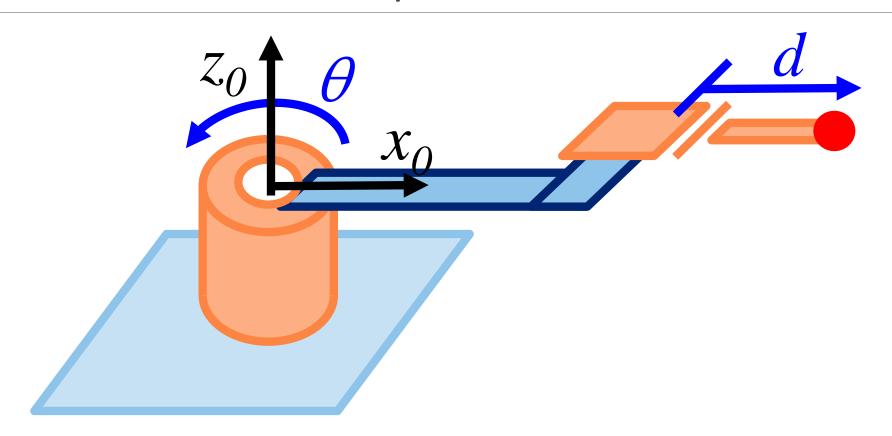








## Kinematics Diagram (3D) Joint Variables - displacement d



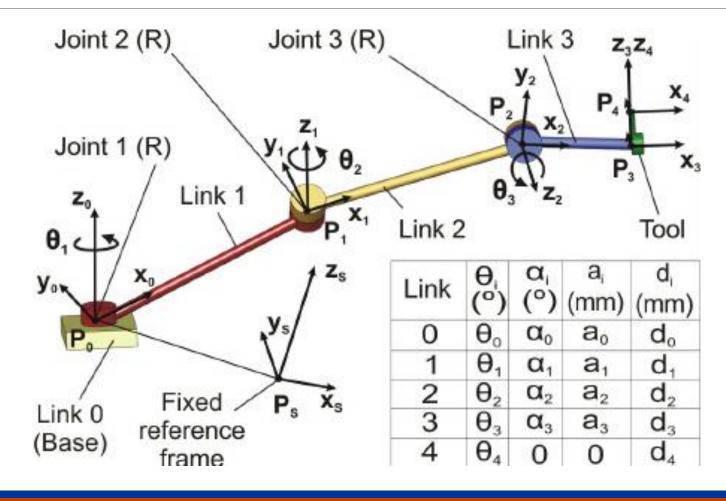


# Kinematics Diagram

SECTION 4 DENAVIT-HARTENBERG PARAMETERS



## Denavit-Hartenberg Parameters



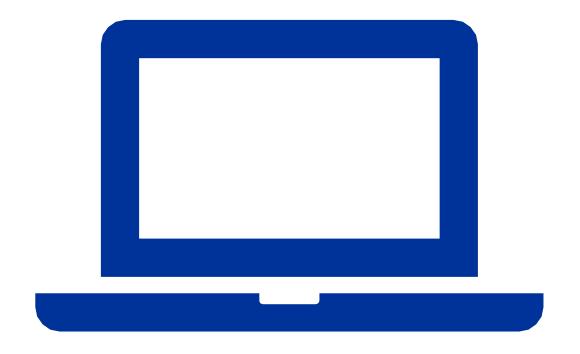




### Denavit-Hartenberg Frames

- •A kinematic Diagram is a kind of drawing that is used in robotics to find the equations we need to control over robot manipulators. In this video, we have investigated several different types of robot manipulators, and learn how to draw kinematics diagrams matching manipulators.
- •Then, you will learn how to draw frames on the kinematics diagrams following four rules known as the "Denavit-Hartenberg" rules.
- •Some programming lab activities and quizzes may follow this dry lab video.





## Demonstration

KD FOR ARM3

## **Example Robot Arm 3**

