



# Introduction to Robotics

Manipulation and Programming

## Unit 2: Kinematics

KINEMATICS DIAGRAM

DR. ERIC CHOU

IEEE SENIOR MEMBER



# Objective

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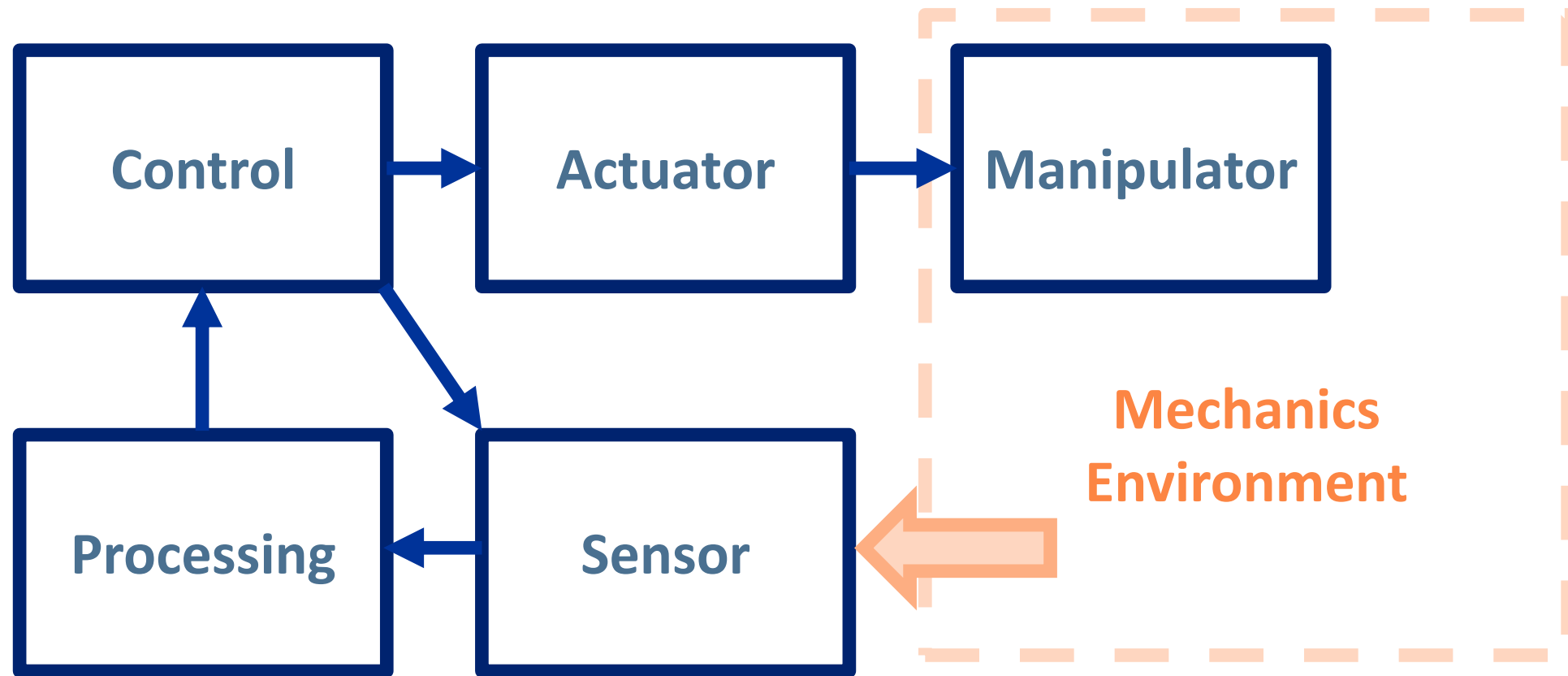
- Learn what is Robot model
- Learn how to draw KD (Kinematics Diagram)

# Robot Model

## SECTION 1



# Robots Computing Model





# Robot Arm is a Manipulator

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- A robot arm receives 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.

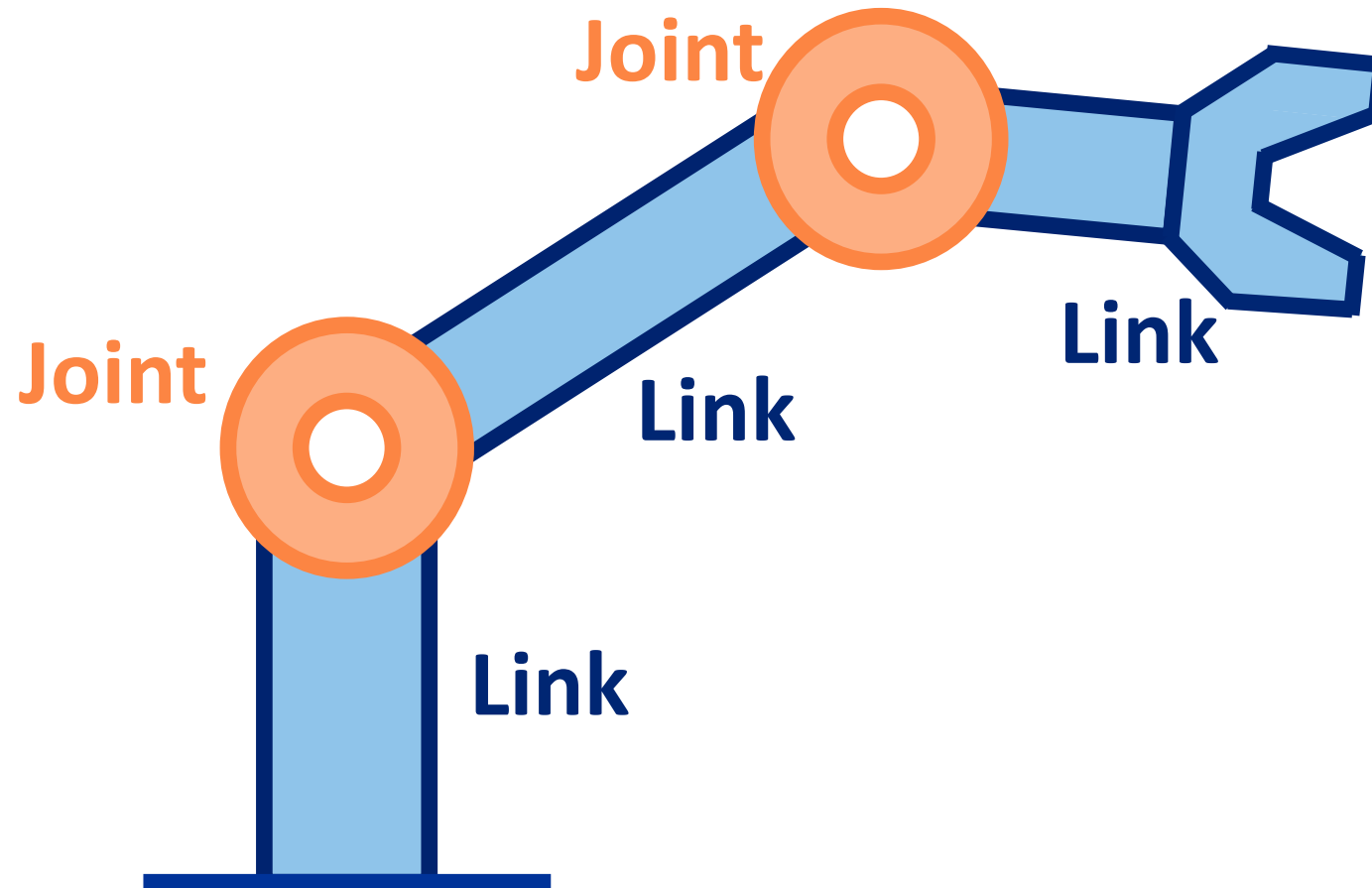
# Kinematics Diagram

## SECTION 2



# Robot Arm consists of Joints and Links

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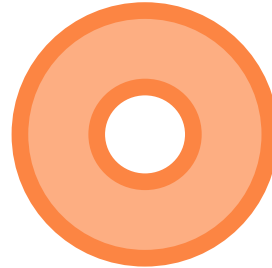


# Robot Arm consists of Joints and Links

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**Prismatic Joint**



**Revolute Joint**



**Link**





# Kinematics Diagram

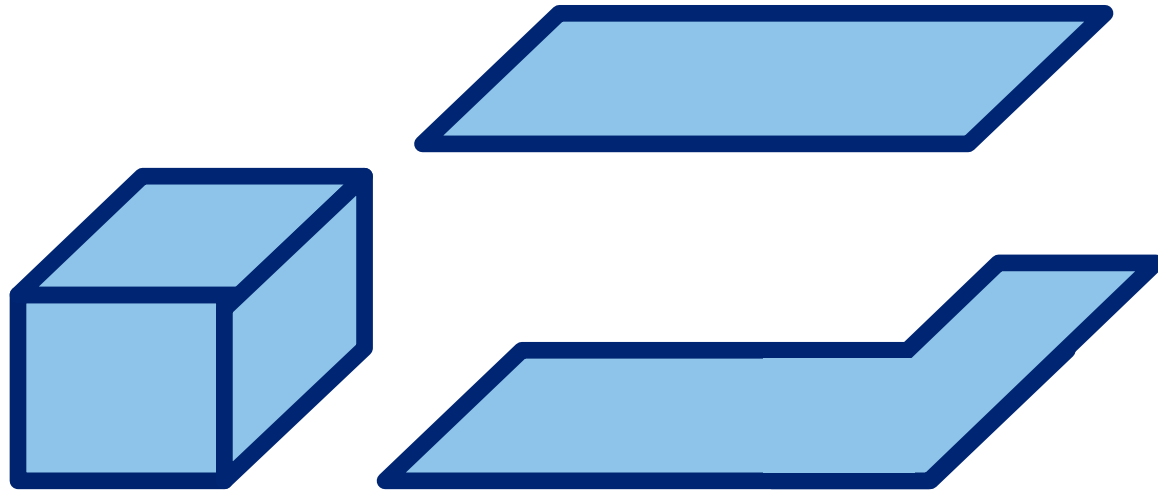
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- 2 D Model
- 3 D Model



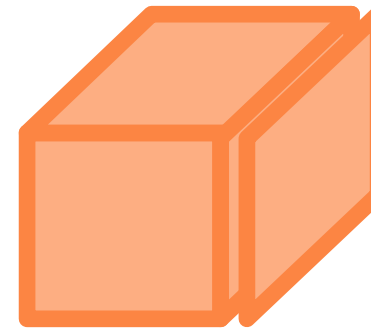
# 3D Model

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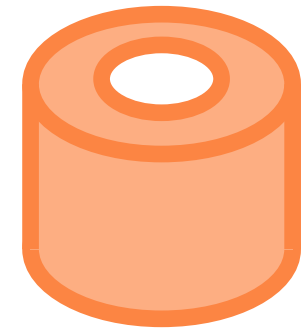


**Block Link**

**Planar Link**

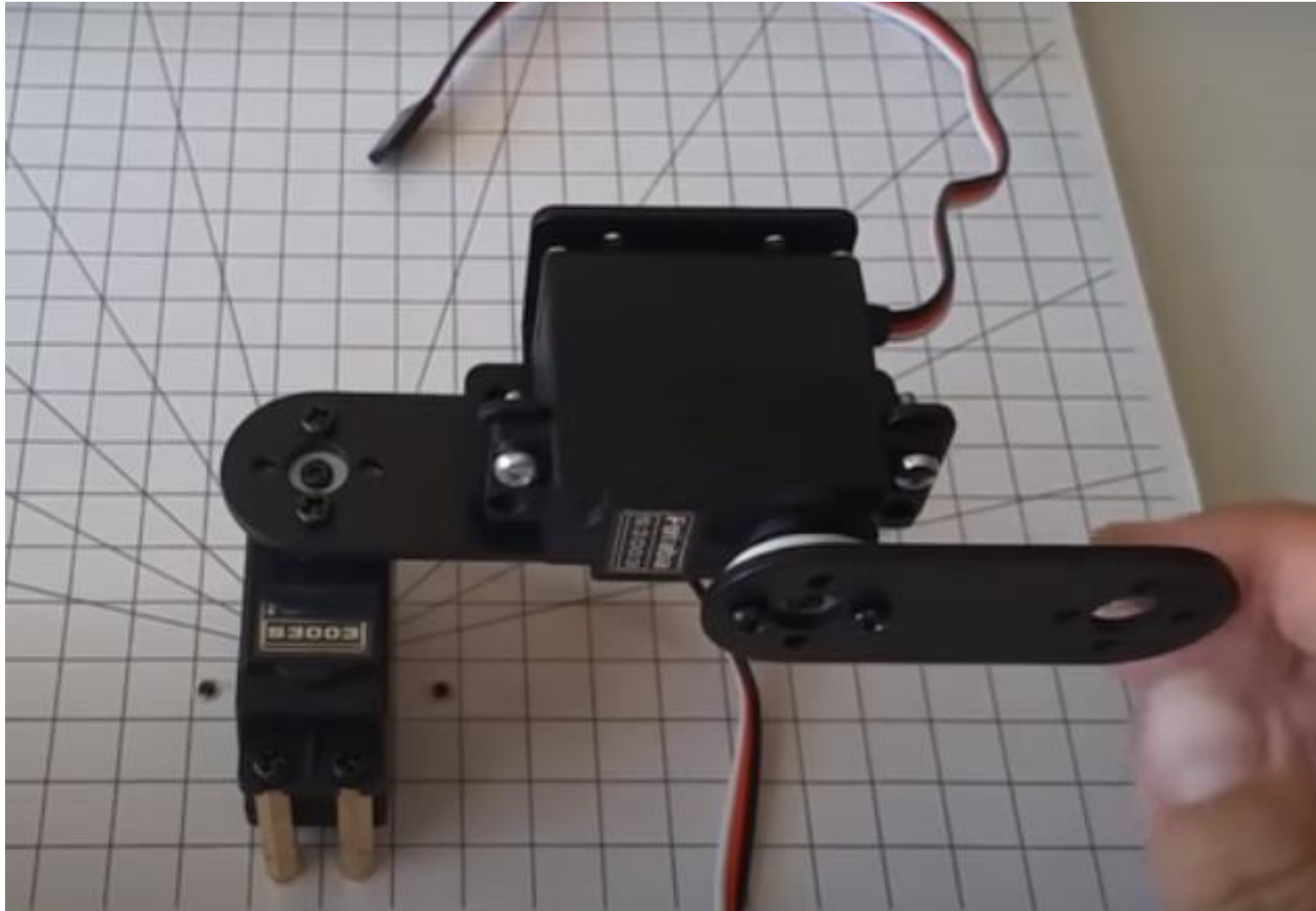


**Prismatic  
Joint**



**Revolute  
Joint**

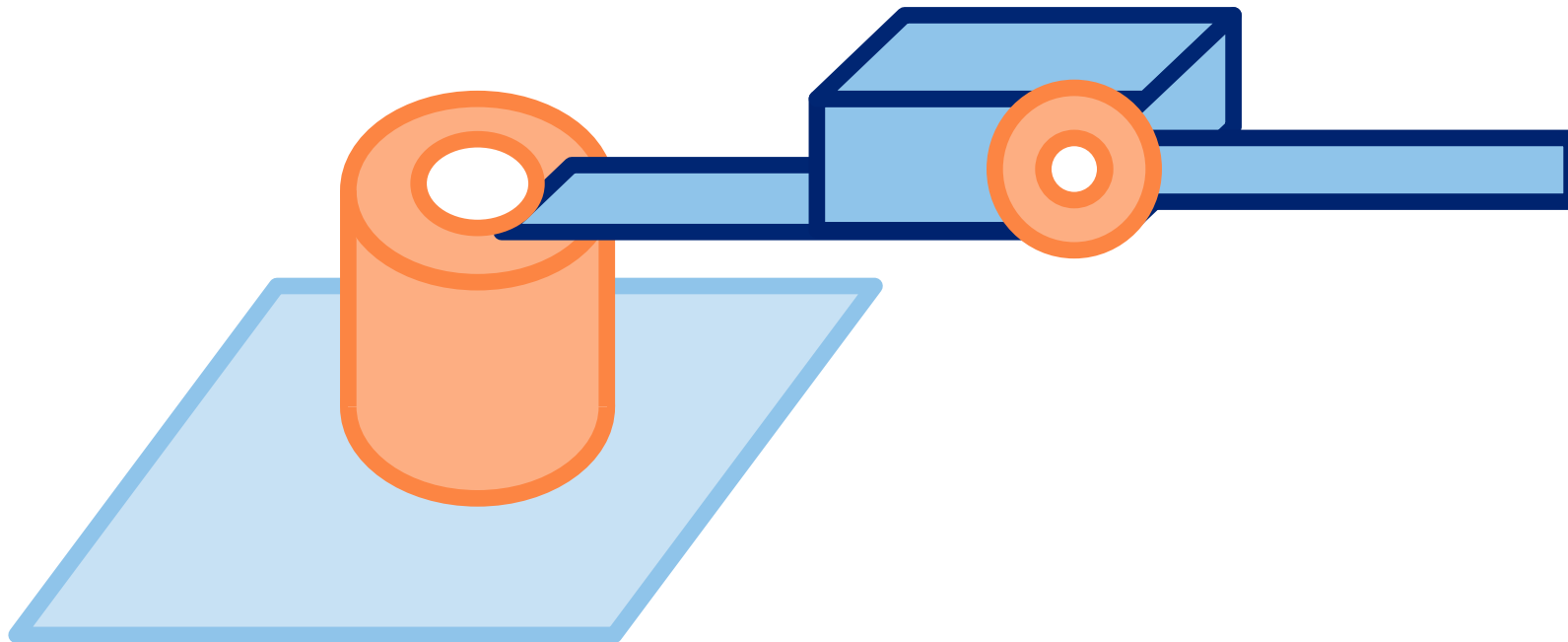
# Example Robot Arm 1





# Kinematics Diagram (3D)

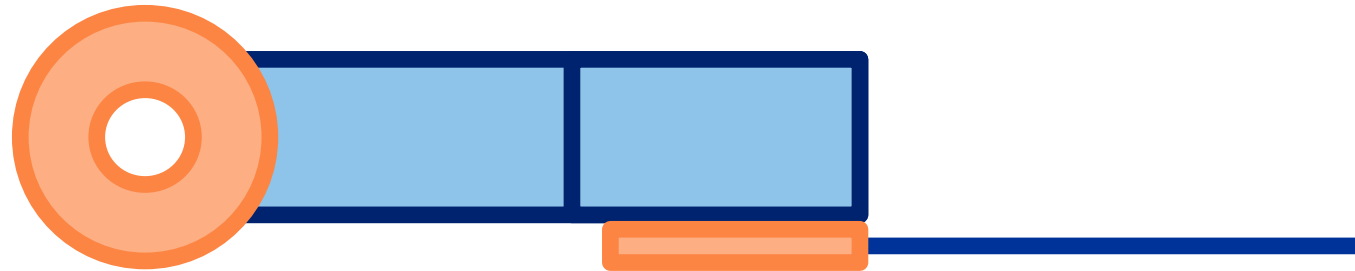
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# Kinematics Diagram (2D Top View)

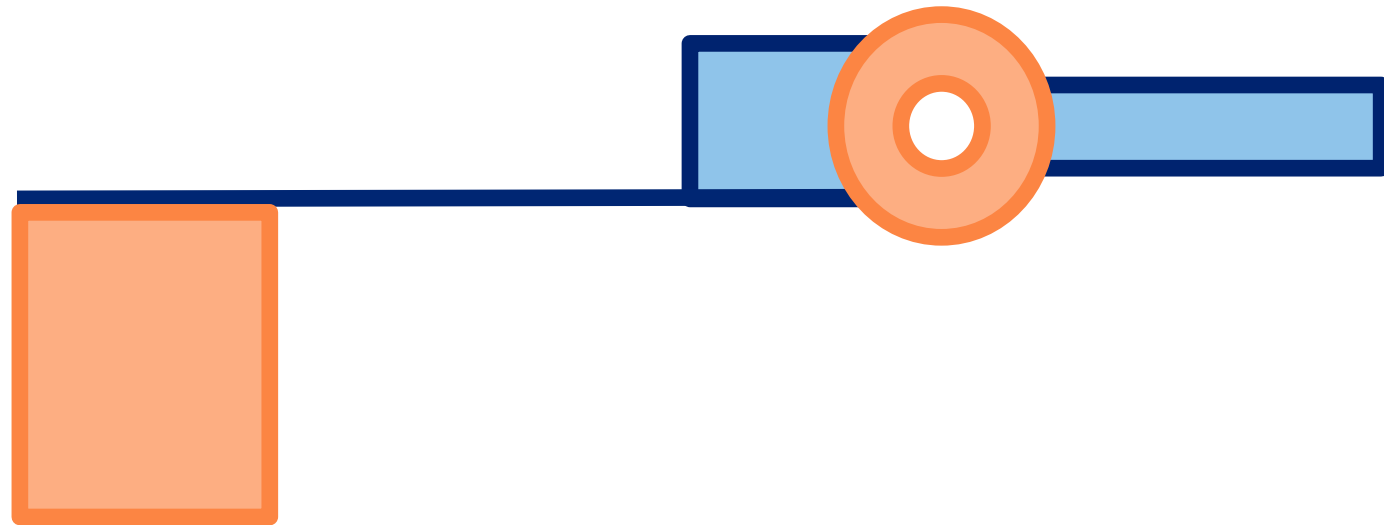
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# Kinematics Diagram (2D From View)

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# Kinematics Diagram

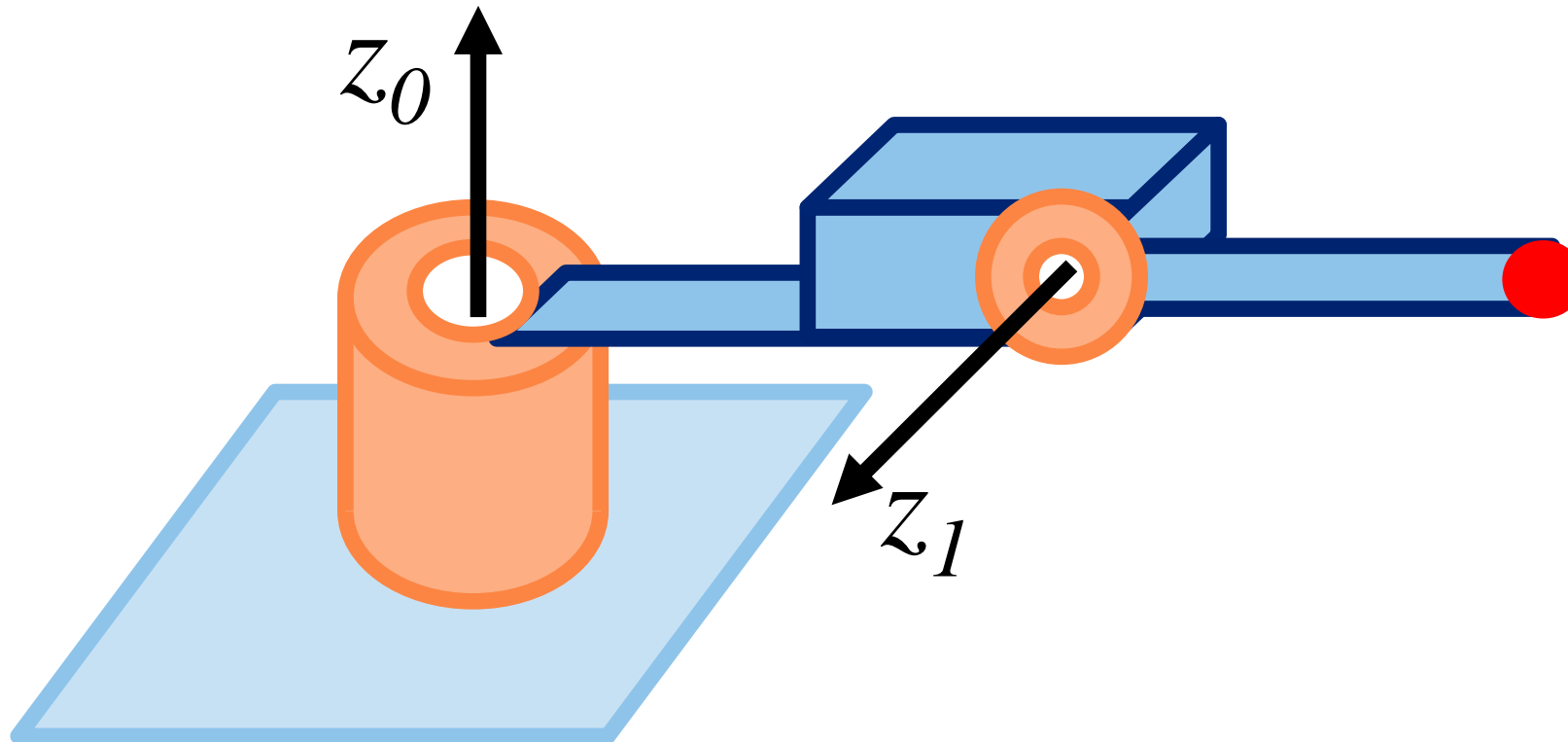
SECTION 3 ASSIGNMENT OF AXIS



# Kinematics Diagram (3D)

Joint (Z)

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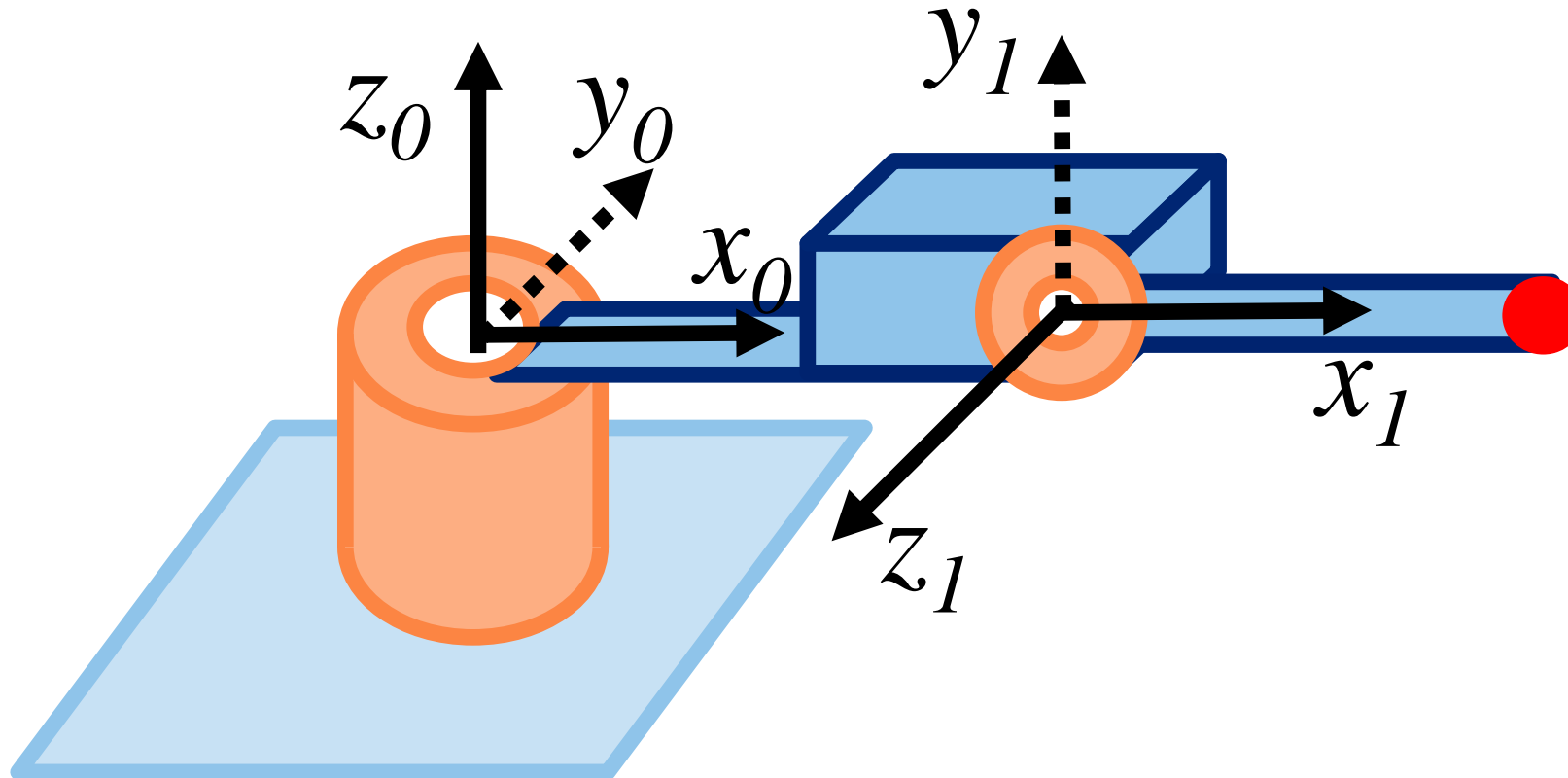
● End Effector





# Kinematics Diagram (3D)

Joint ( $x$ )

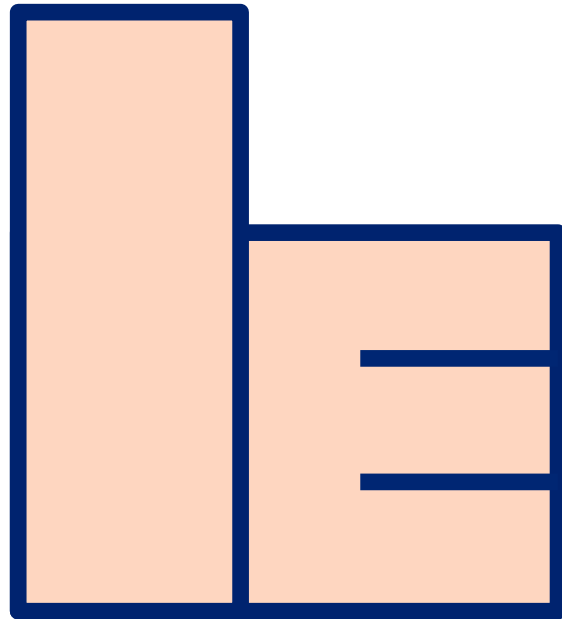


● End Effector

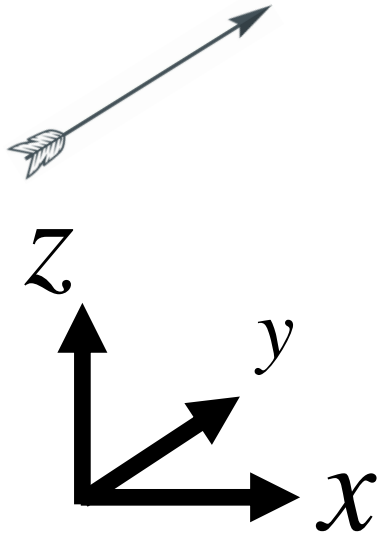


# Right Hand Rule

**Thumb**

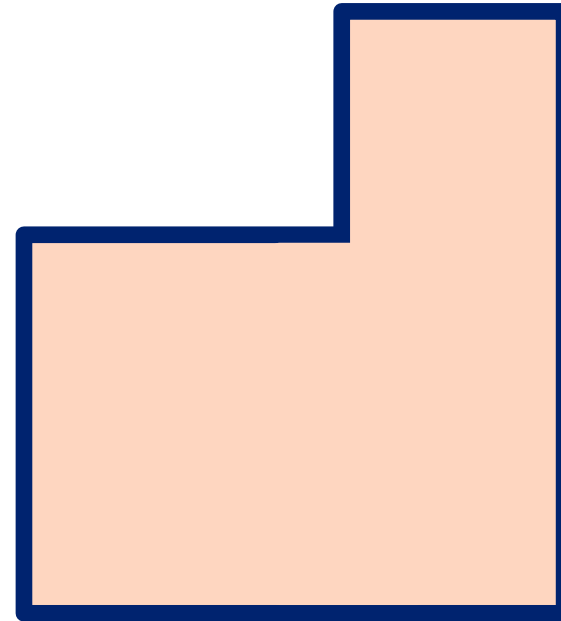


**Hand Back**

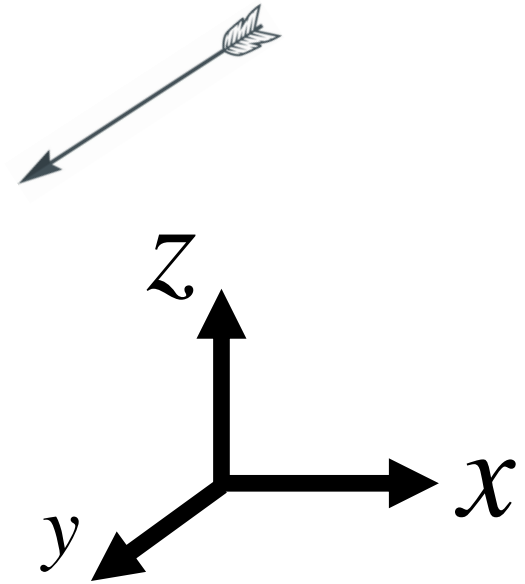


Into paper

**Thumb**



**Hand Palm**

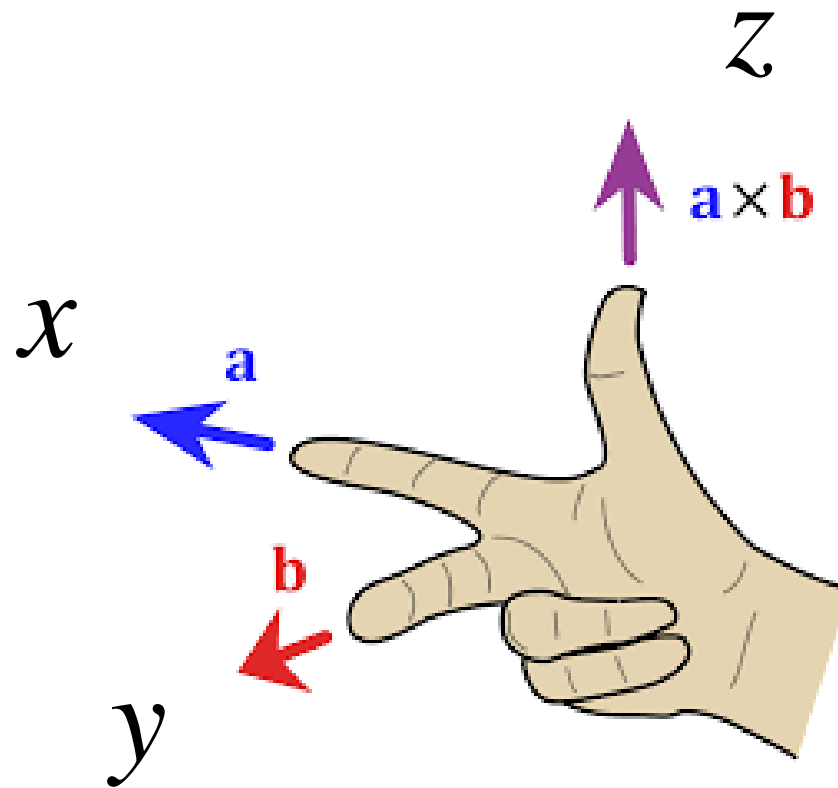


Out of Paper



# Right Hand Rule

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# Rule # 1:

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



## Rule # 2:

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- 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:

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



## Rule # 4:

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

# Kinematics Diagram

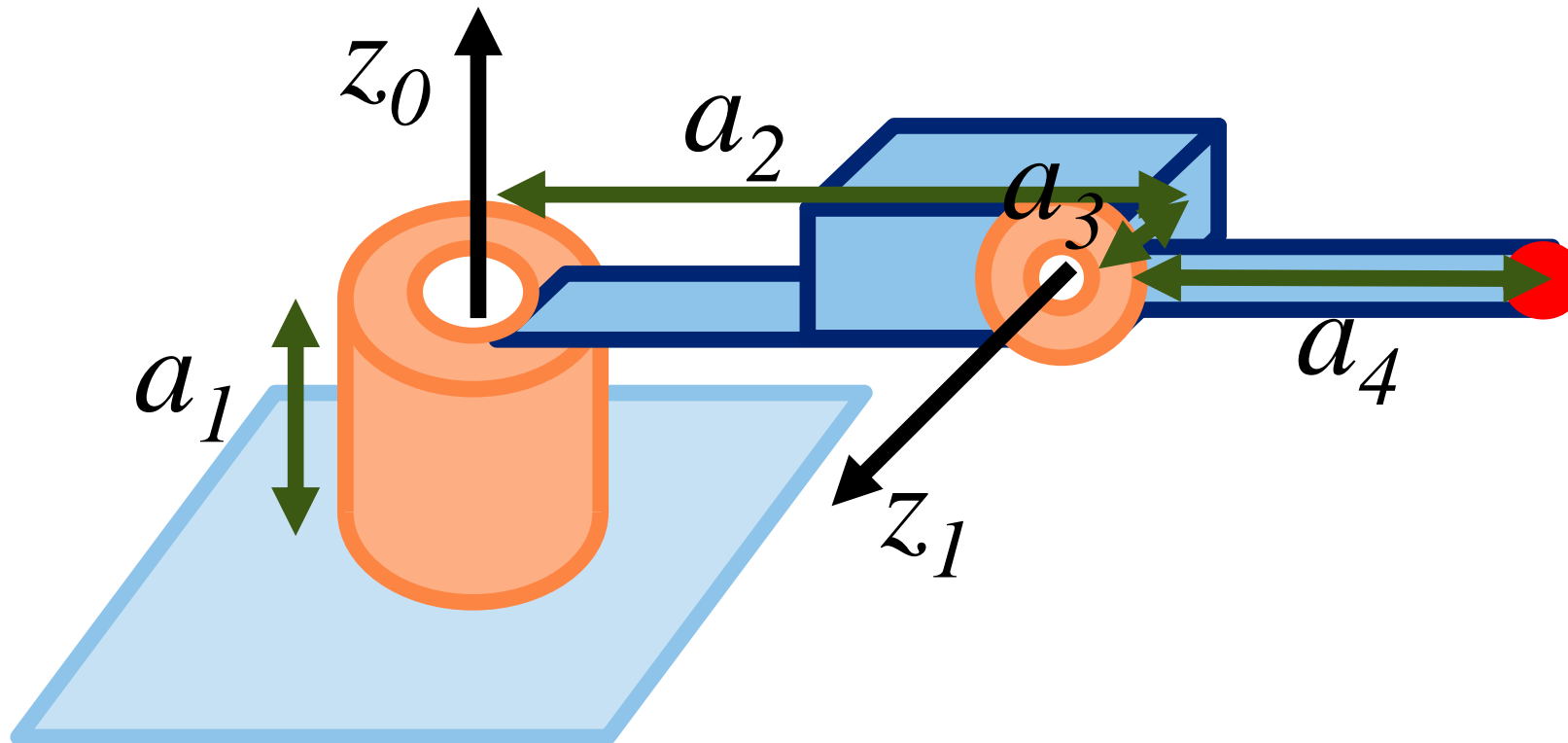
SECTION 3 PARAMETERS AND VARIABLES





# Kinematics Diagram (3D)

Parameters (a: distance from the previous joint)

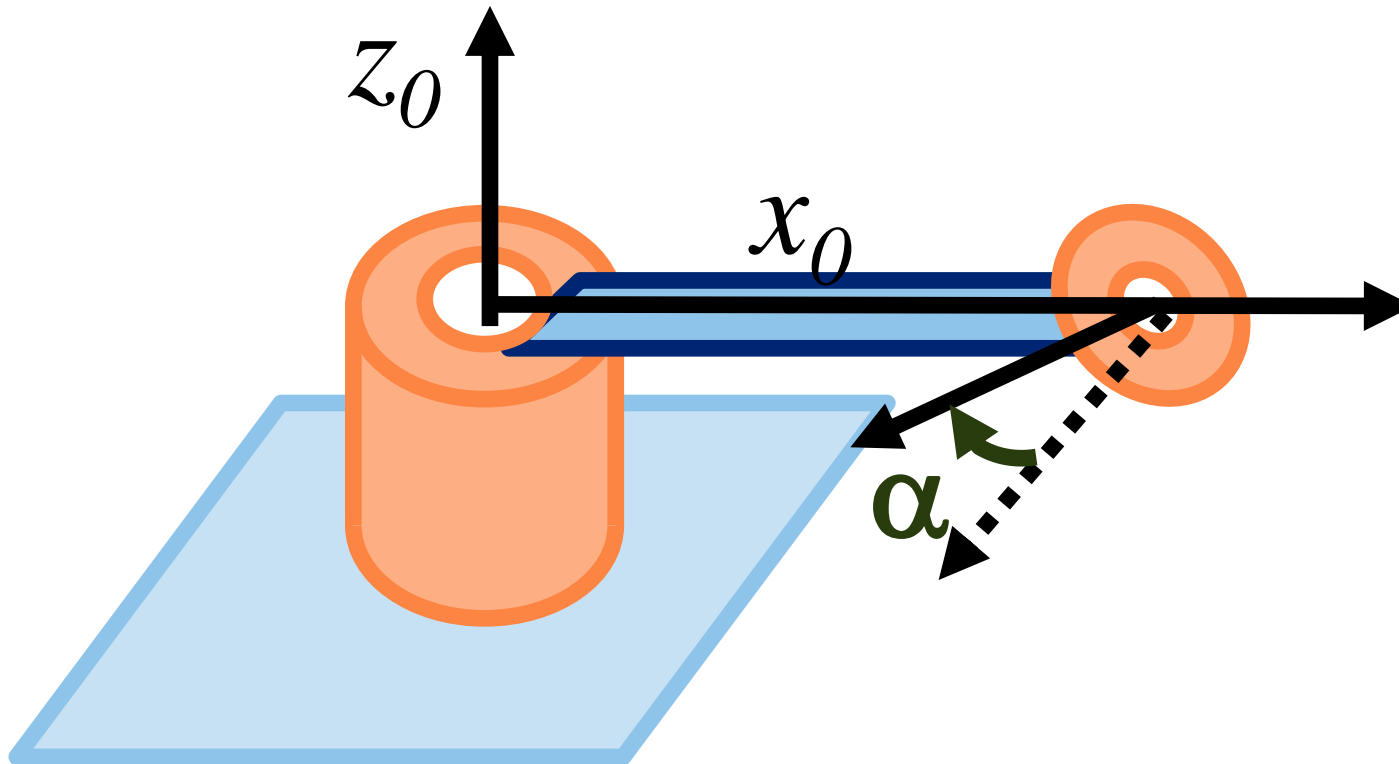


● End Effector



# Kinematics Diagram (3D)

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



● End Effector

# Example Robot Arm 2





# Joint Variable

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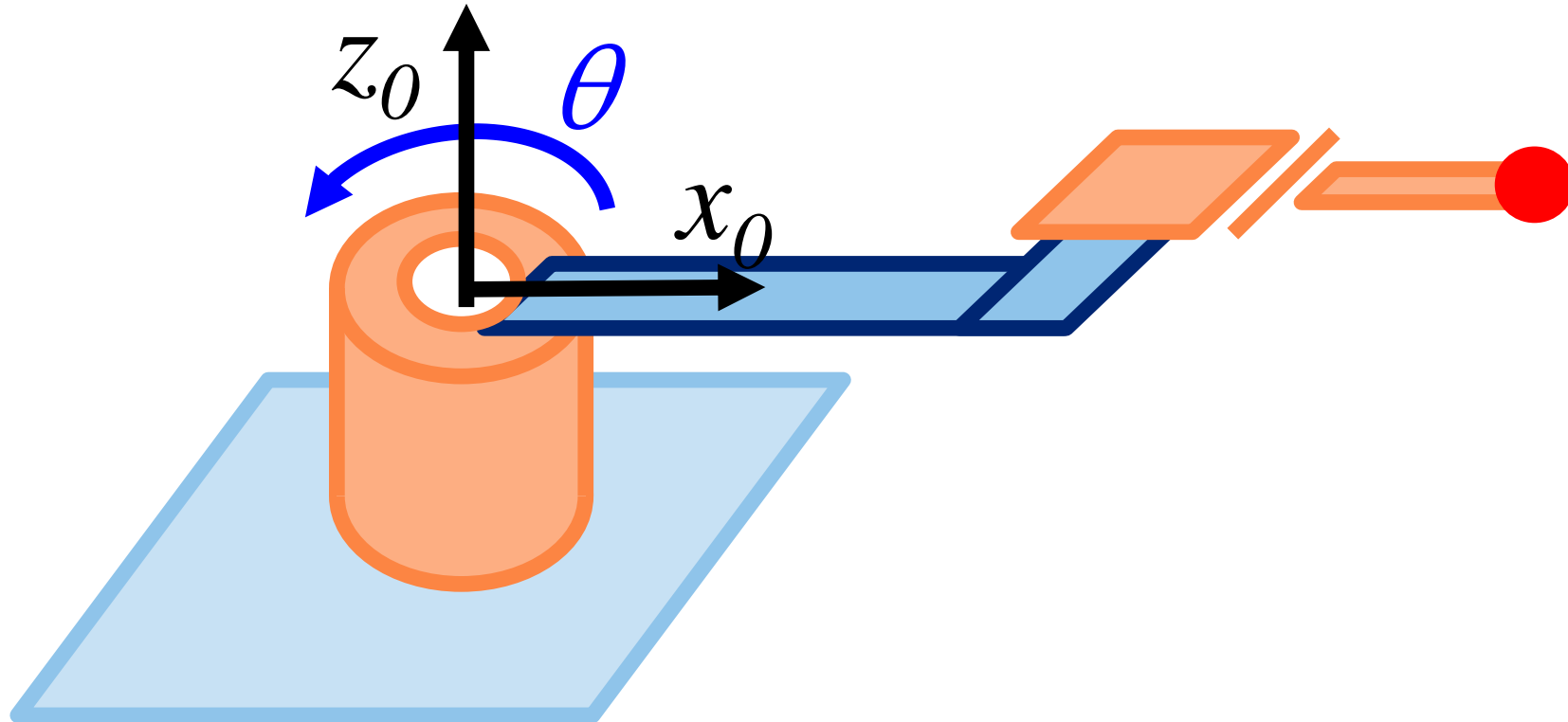
- The value that changes when a joint moves.



# Kinematics Diagram (3D)

## Joint Variables - angle $\theta$

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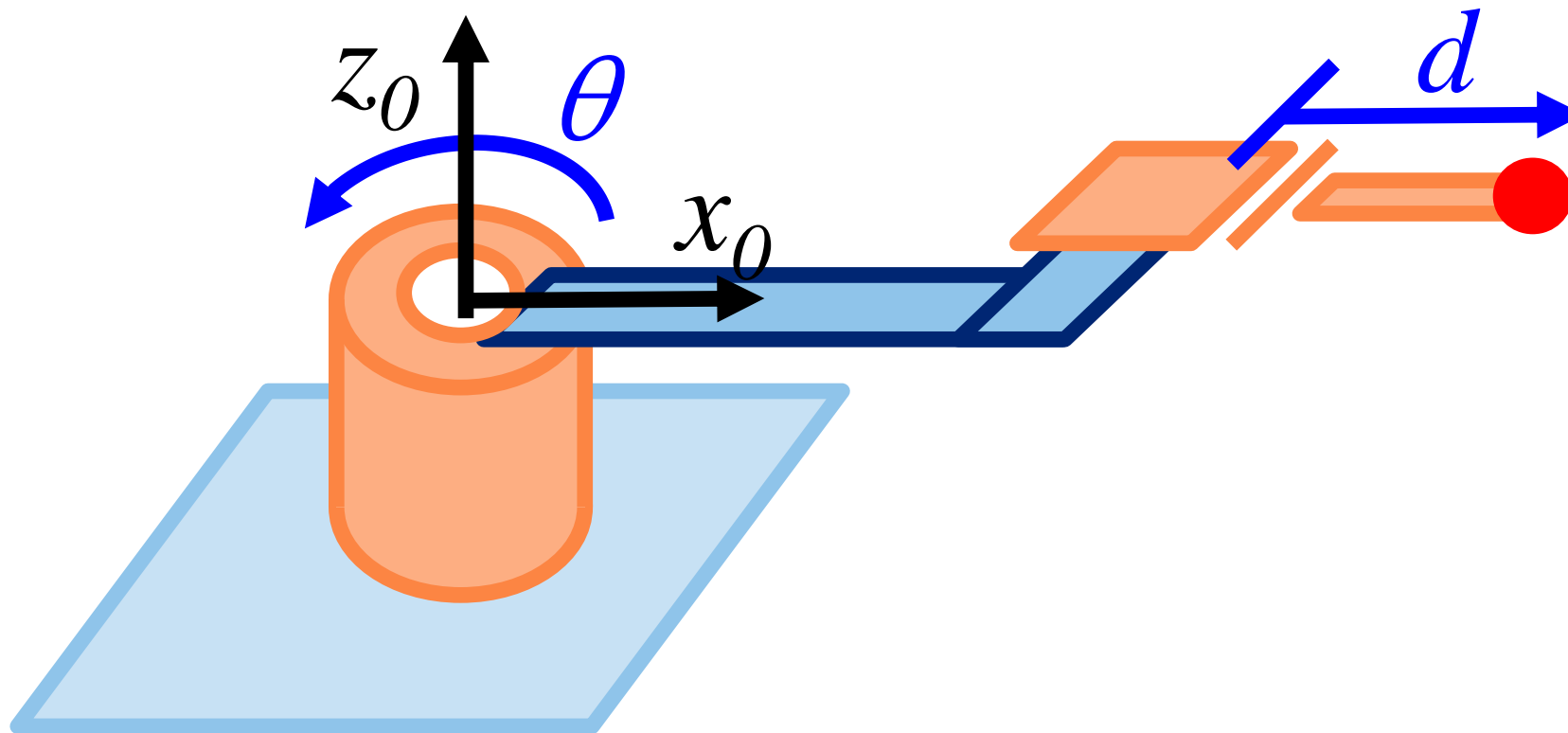
● End Effector



# Kinematics Diagram (3D)

## Joint Variables - displacement $d$

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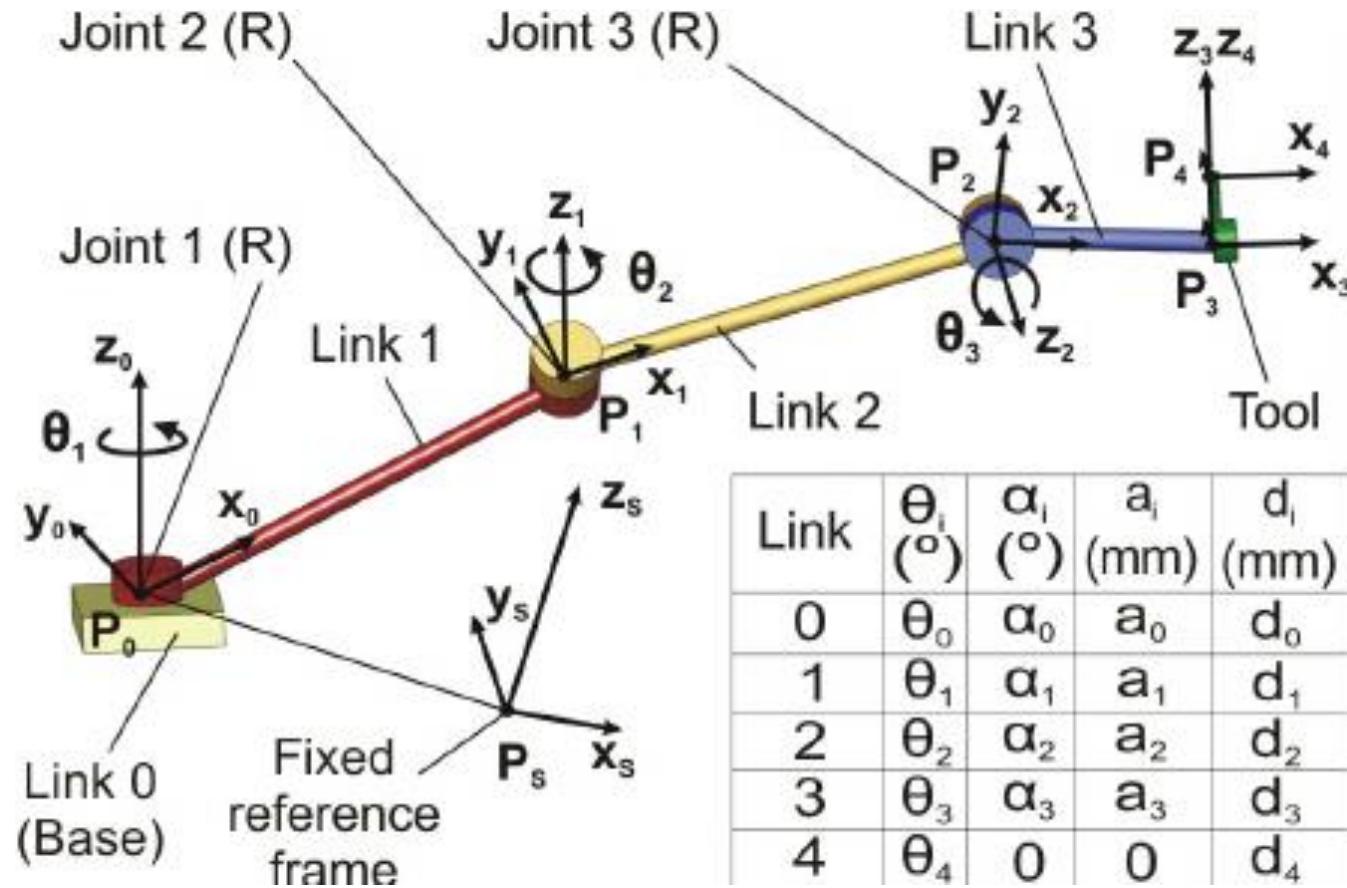
● End Effector

# Kinematics Diagram

SECTION 4 DENAVIT-HARTENBERG PARAMETERS



# Denavit-Hartenberg Parameters



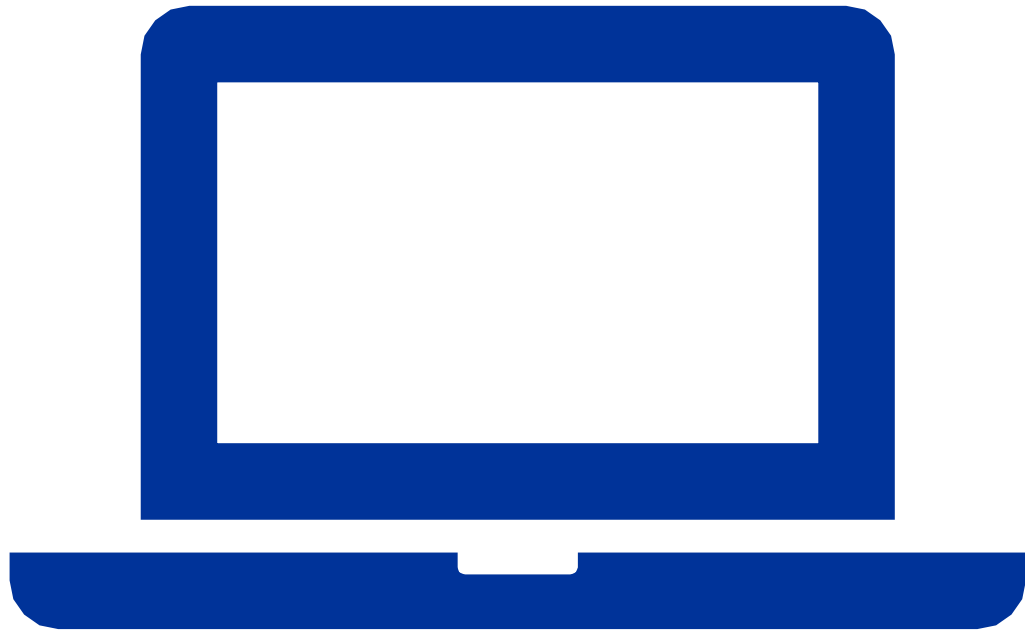




# Denavit-Hartenberg Frames

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- 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

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KD FOR ARM3

# Example Robot Arm 3

