Introduction to Robotics

Manipulation and Programming

Unit 2: Kinematics

KINEMATICS DIAGRAM

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IEEE SENIOR MEMBER

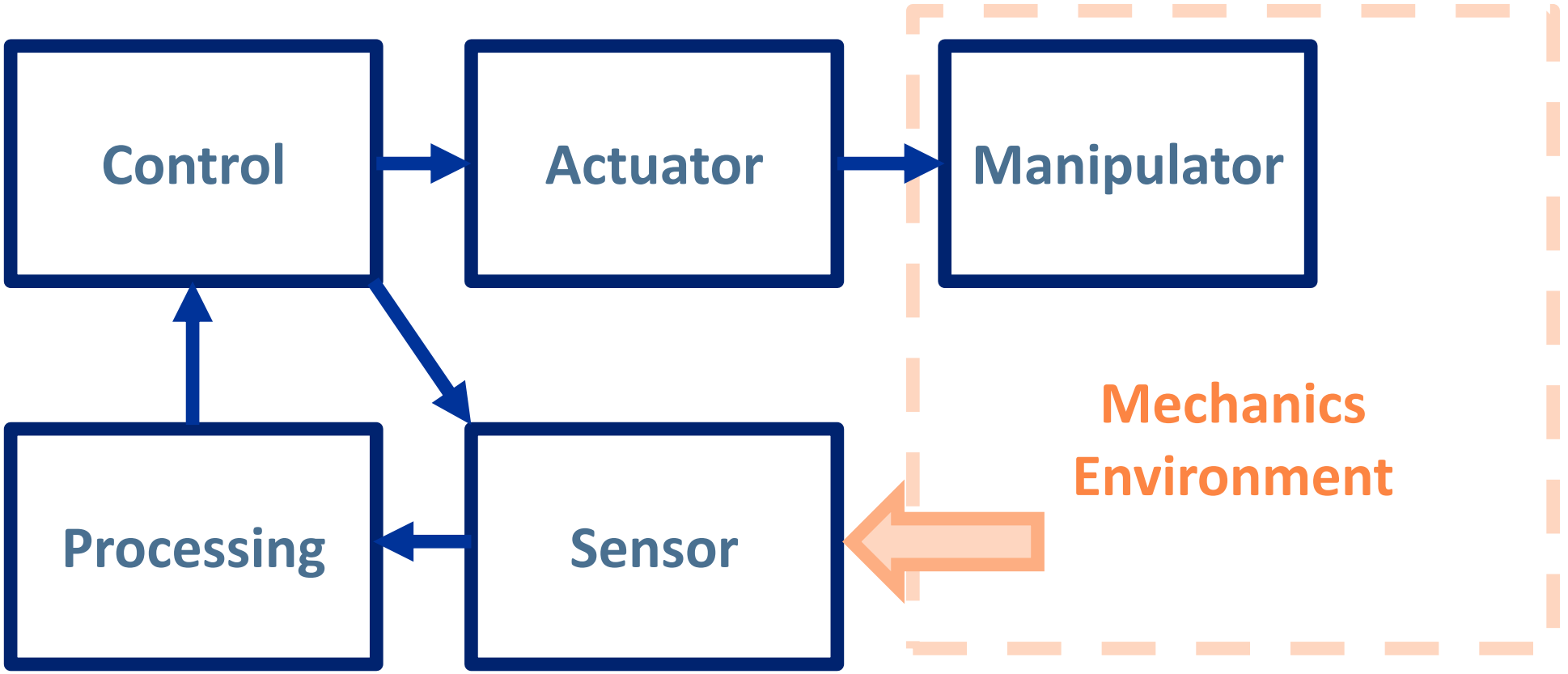
Objective

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

Robot Model

SECTION 1

Robots Computing Model



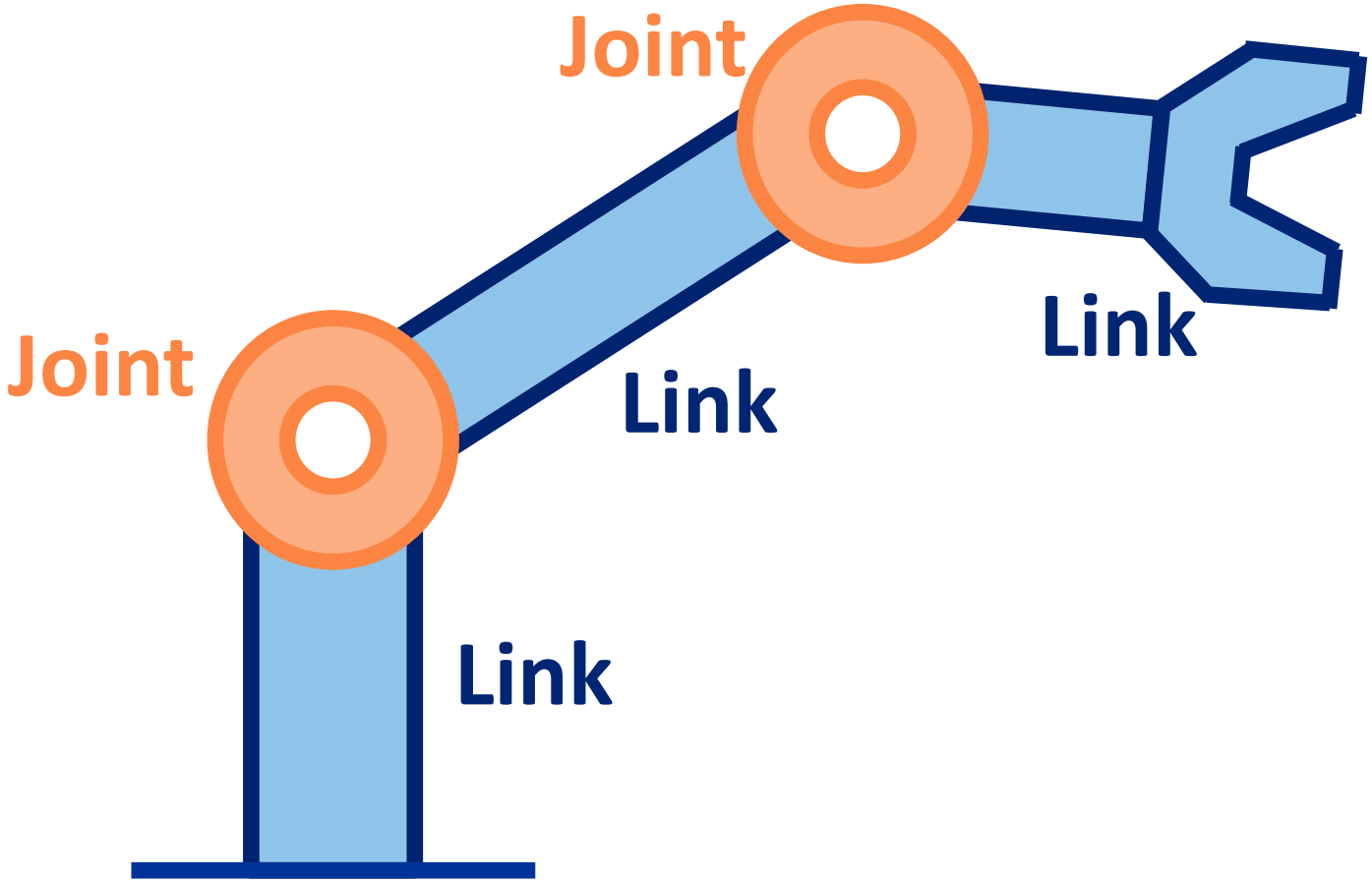
Robot Arm is a Manipulator

- 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

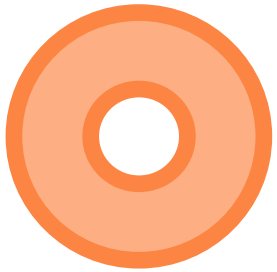
SECTION 2

Robot Arm consists of Joints and Links



Robot Arm consists of Joints and Links

Prismatic Joint



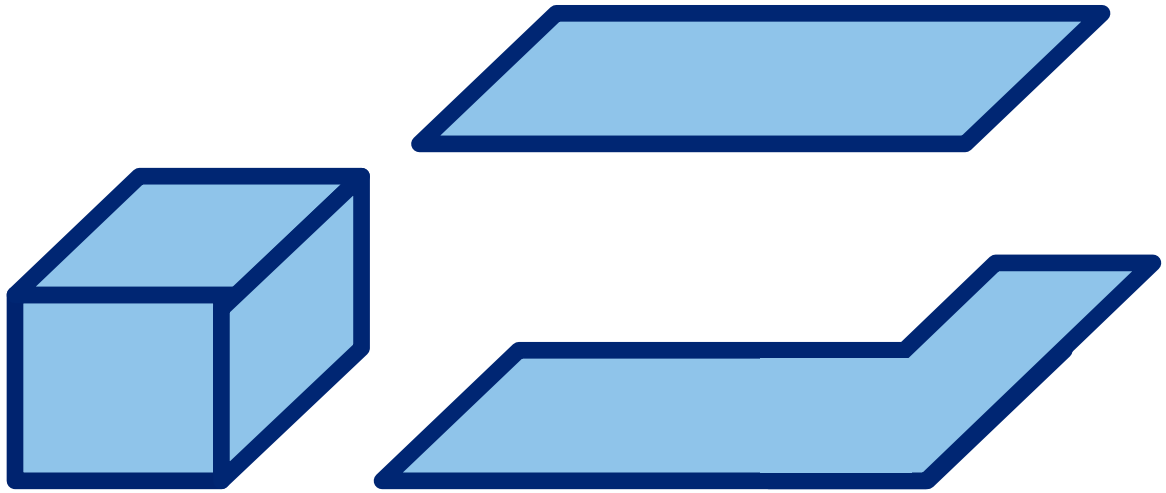
Revolute Joint

Link

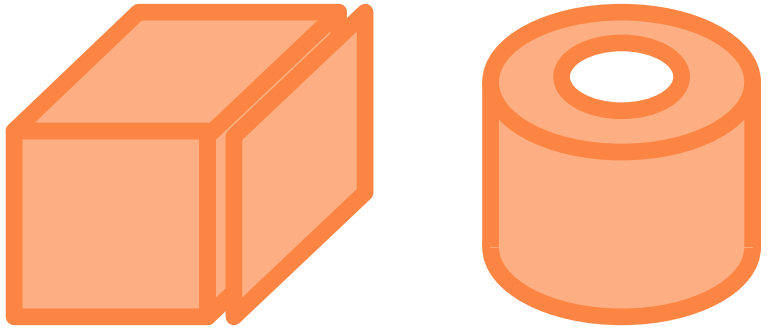
Kinematics Diagram

- 2 D Model
- 3 D Model

3D Model

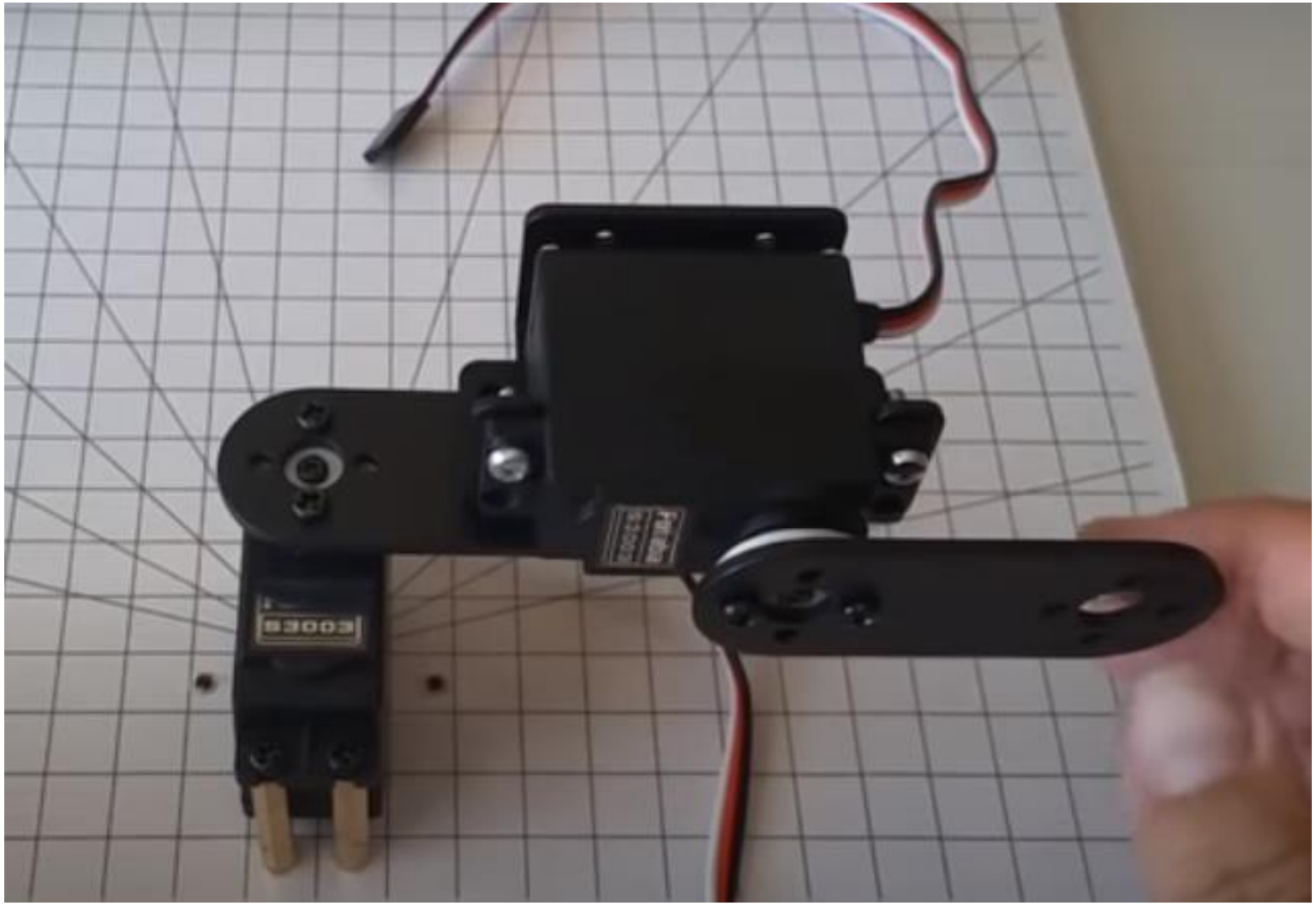


Block Link **Planar Link**

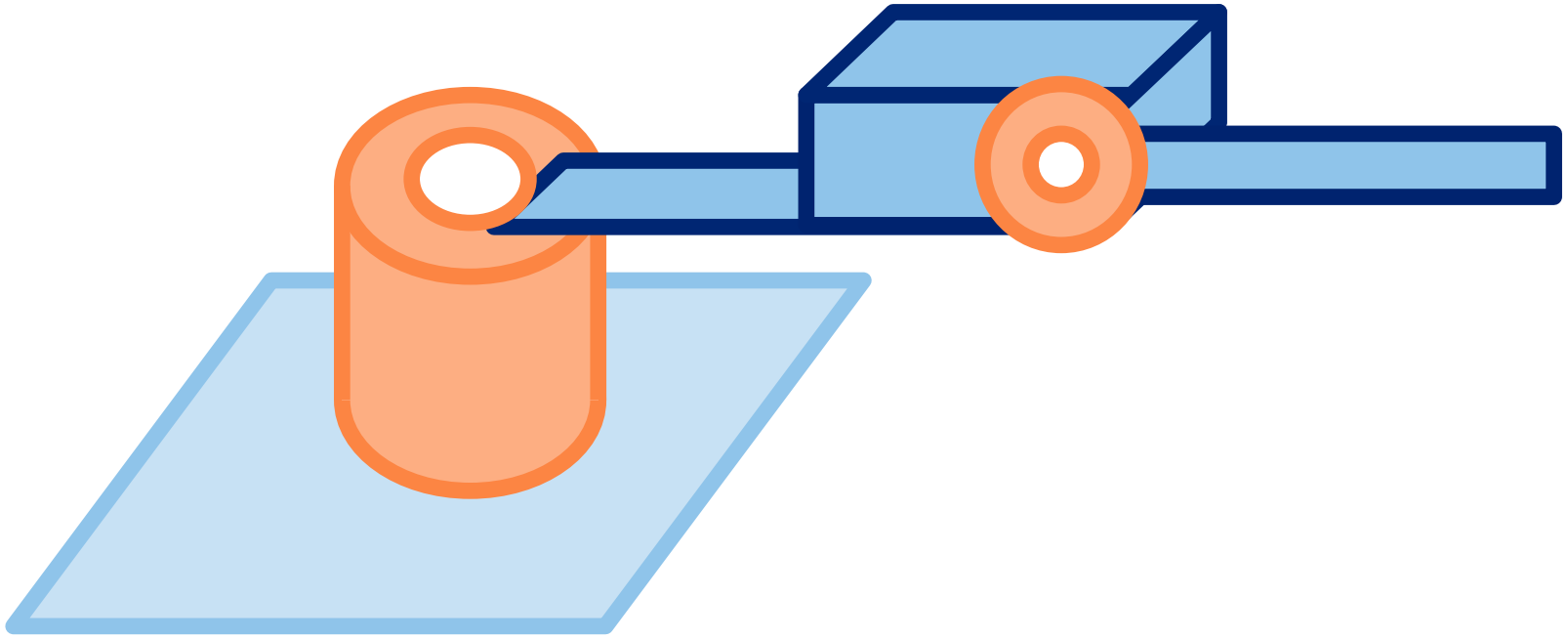


Prismatic Joint **Revolute Joint**

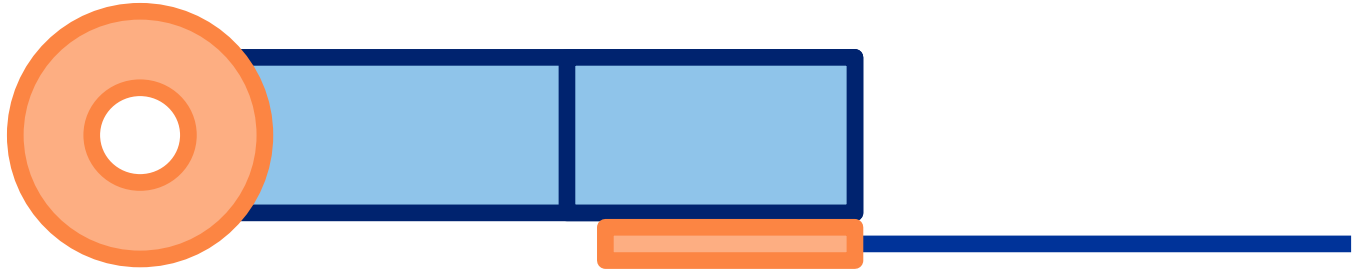
Example Robot Arm 1



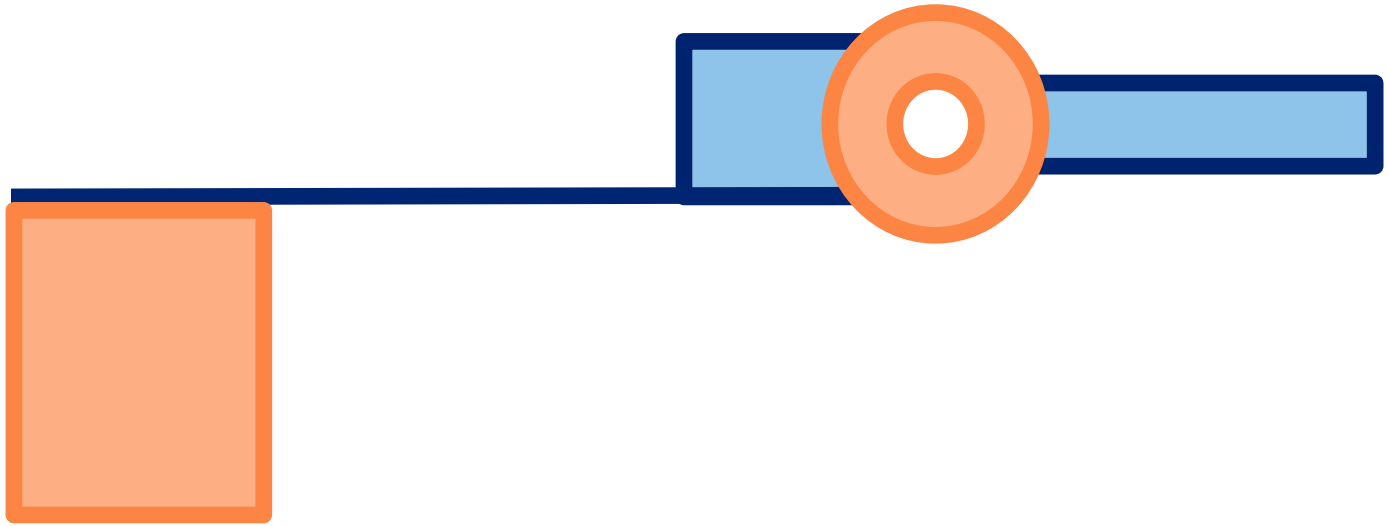
Kinematics Diagram (3D)



Kinematics Diagram (2D Top View)



Kinematics Diagram (2D From View)

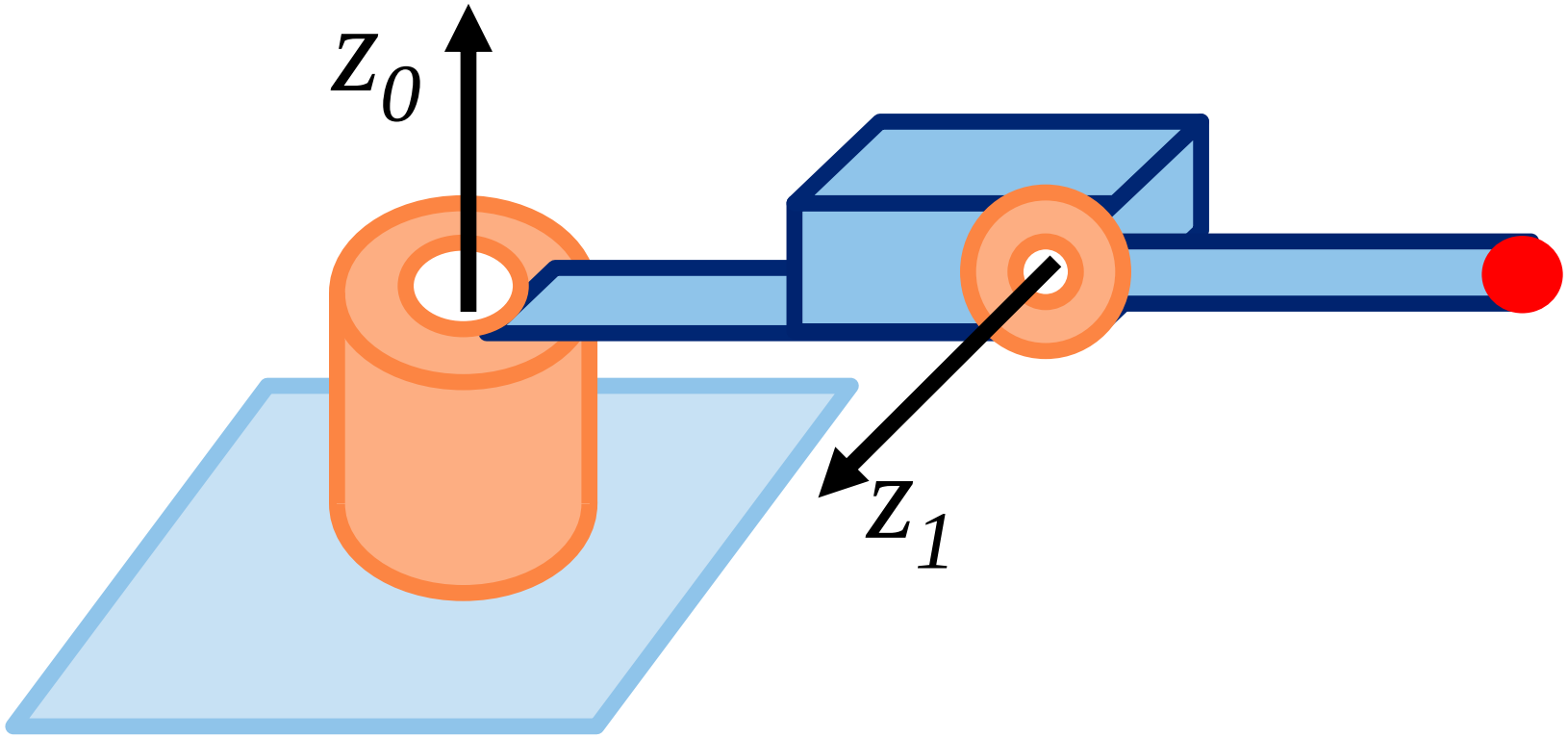


Kinematics Diagram

SECTION 3 ASSIGNMENT OF AXIS

Kinematics Diagram (3D)

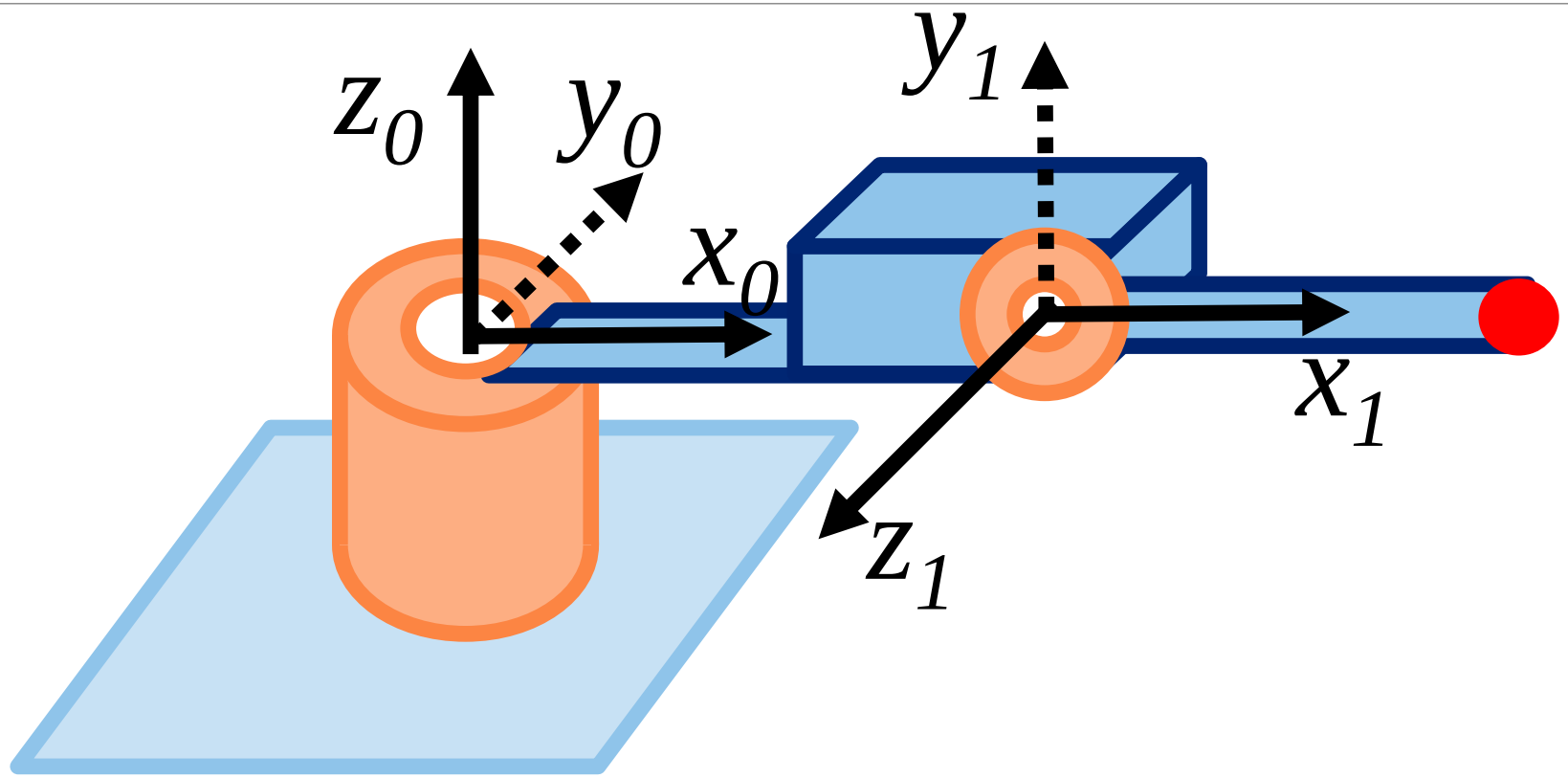
Joint (Z)



End Effector

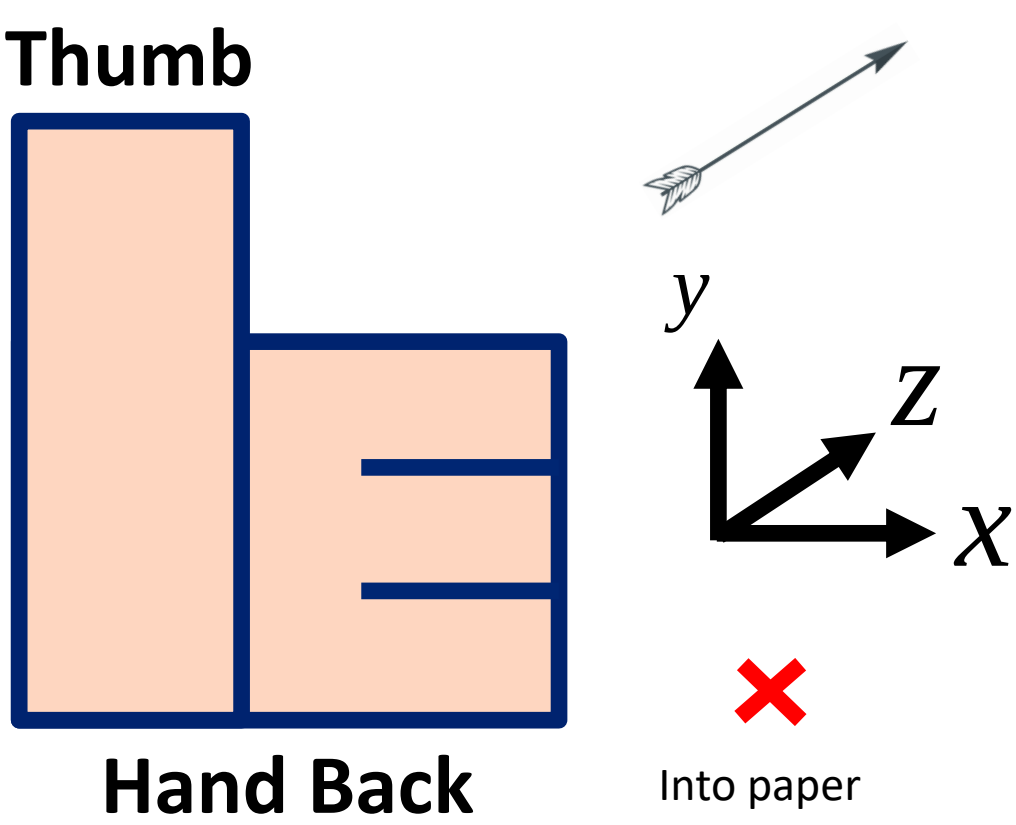
Kinematics Diagram (3D)

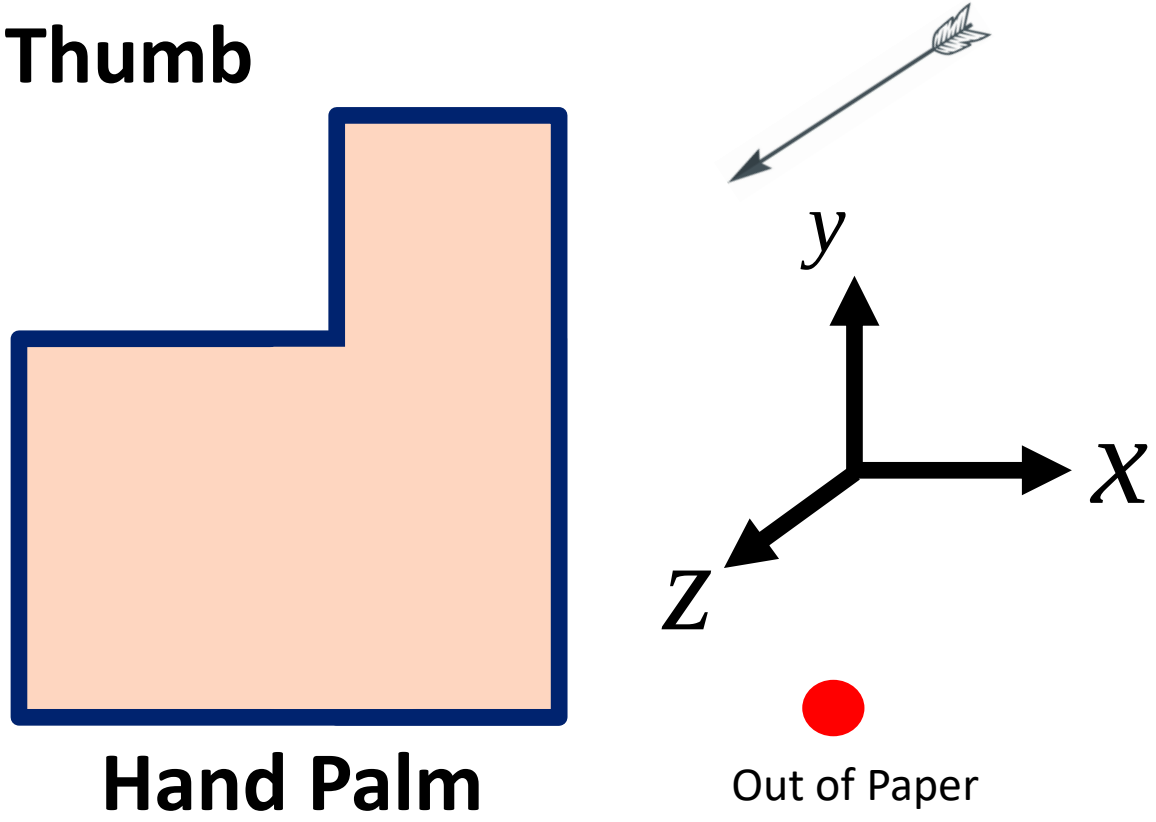
Joint (x)



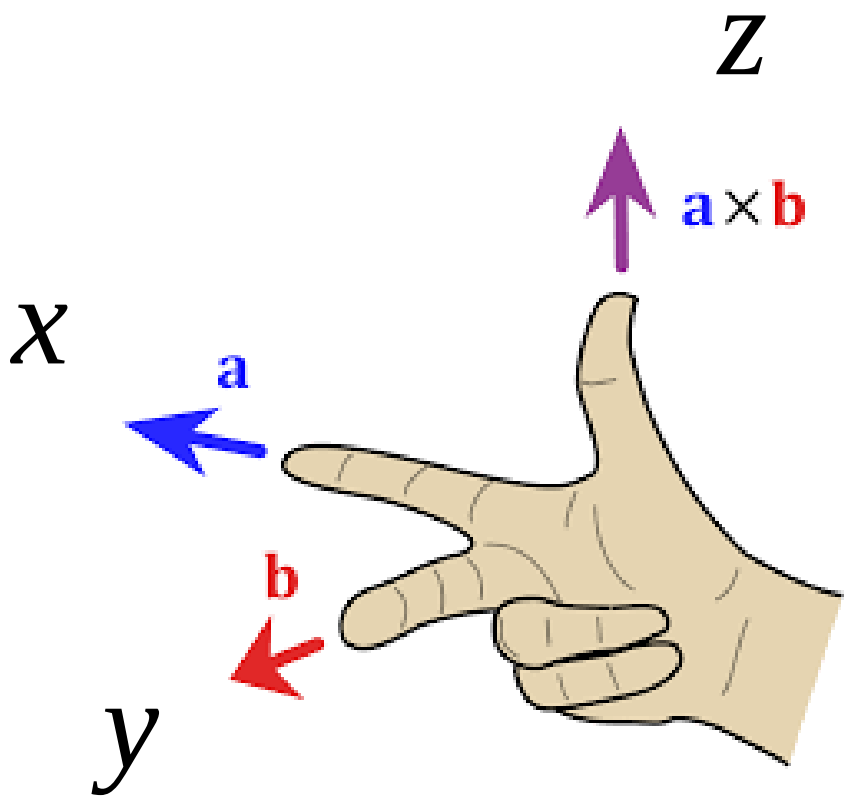
End Effector

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:

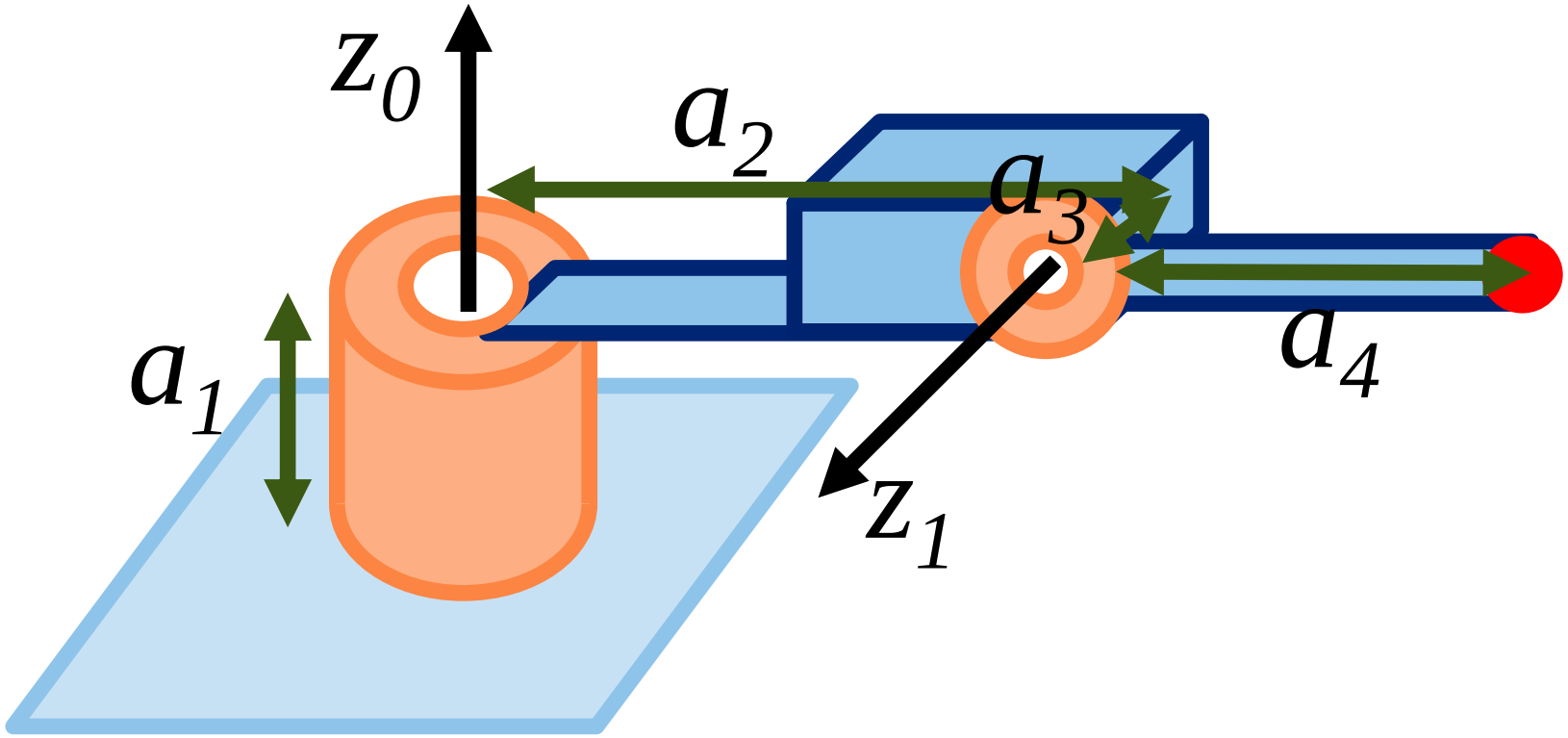
- Each X-axis must intersect the Z-axis of the frame before it.

Kinematics Diagram

SECTION 3 PARAMETERS AND VARIABLES

Kinematics Diagram (3D)

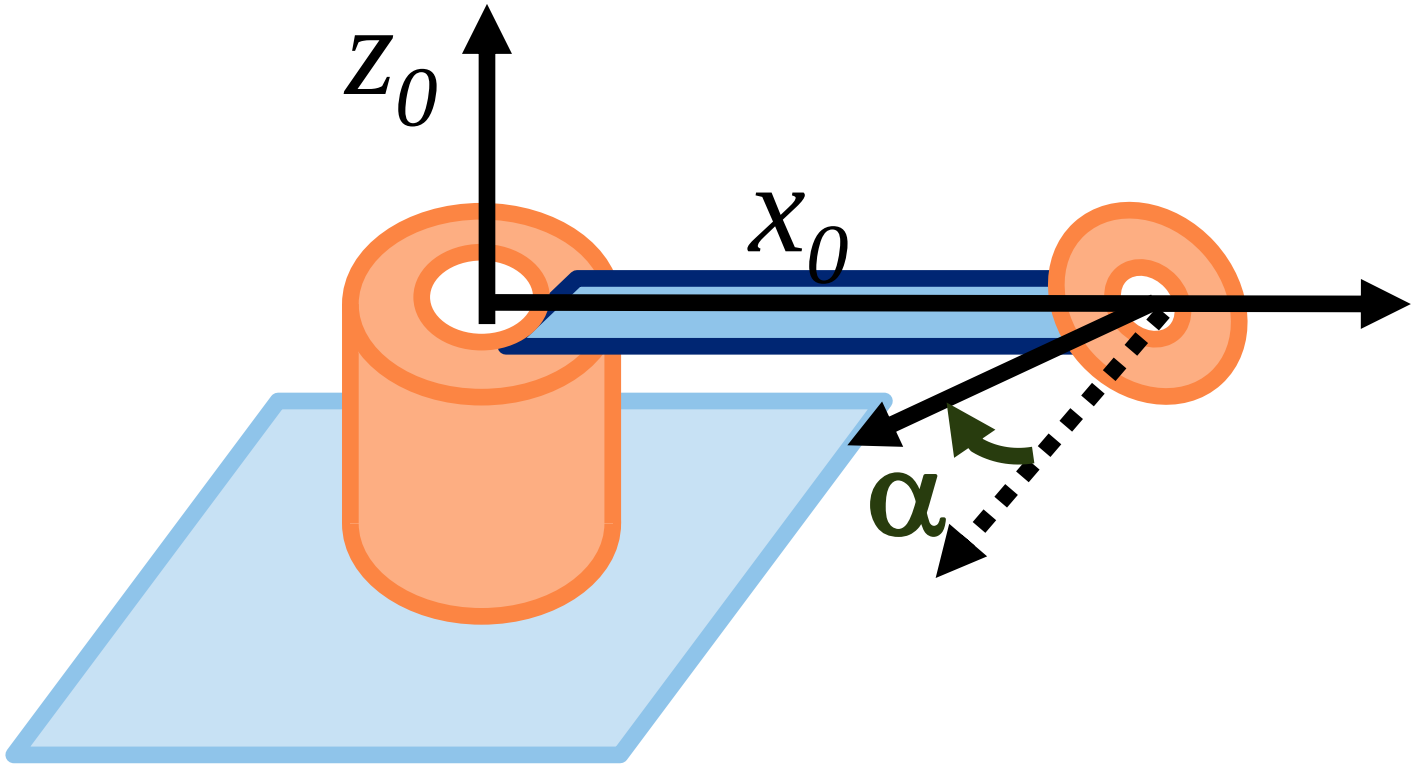
Parameters (a: distance from the previous joint)



End Effector

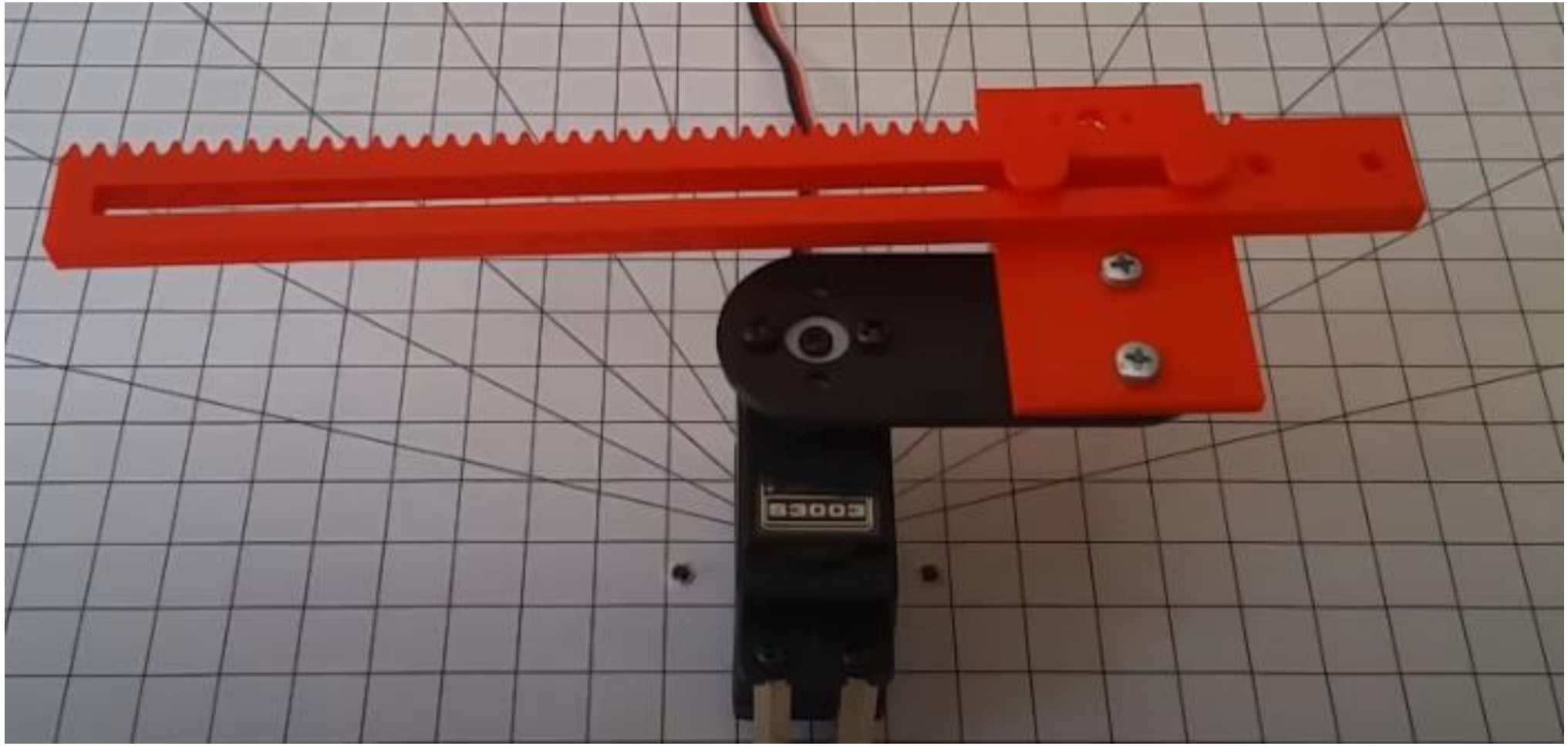
Kinematics Diagram (3D)

Parameters (α: angle of a z joint to previous x axis)



End Effector

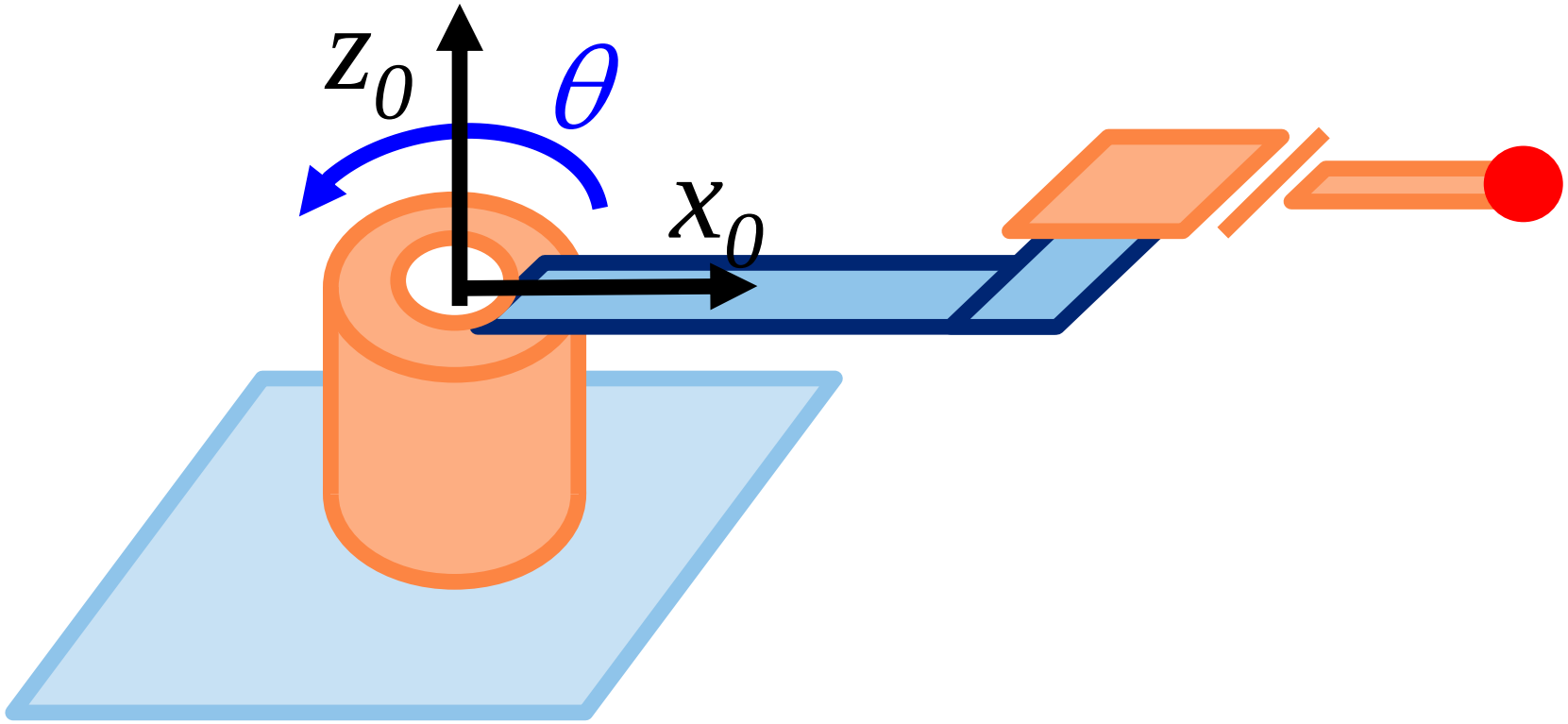
Example Robot Arm 2



Joint Variable

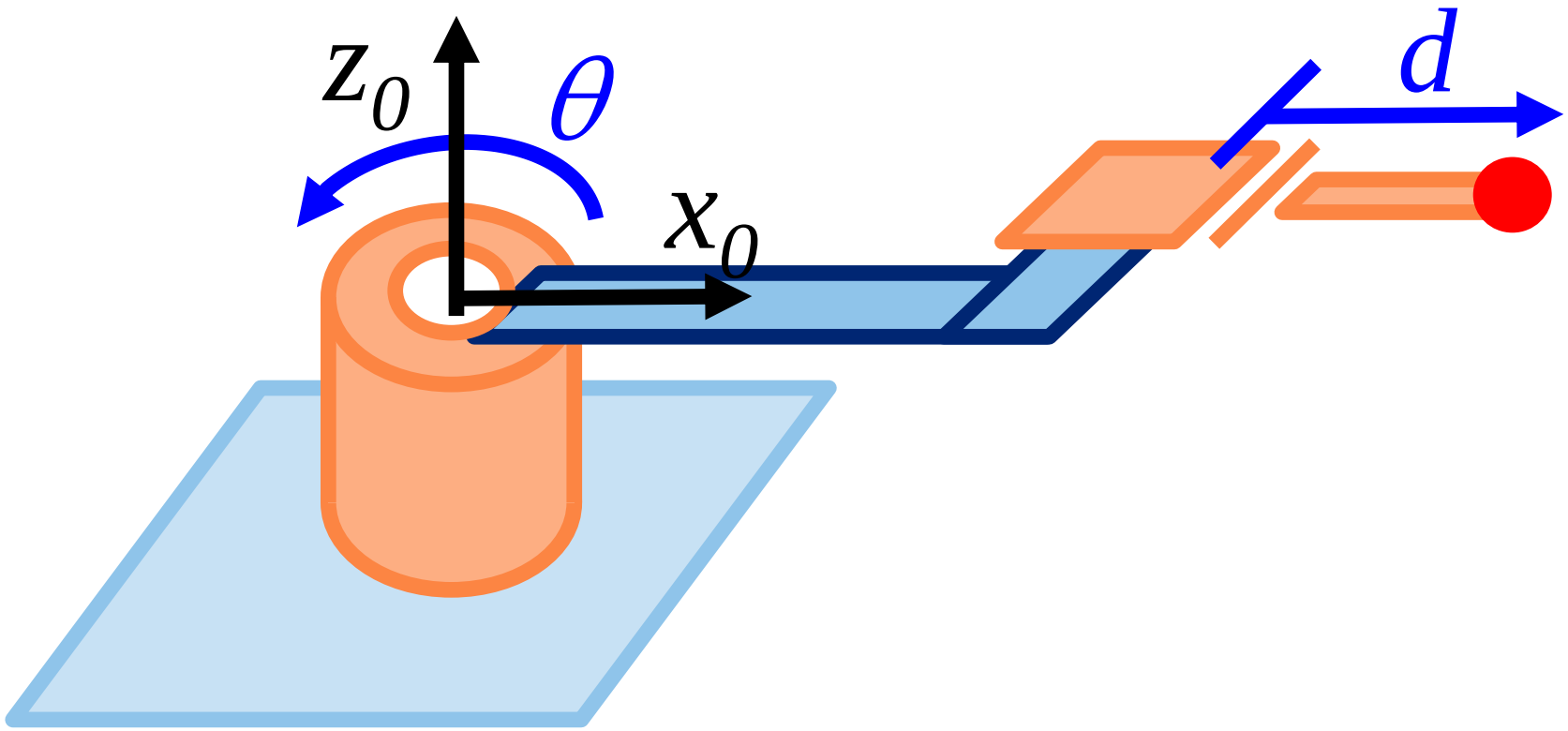
- The value that changes when a joint moves.

Kinematics Diagram (3D)
Joint Variables - angle θ



End Effector

Kinematics Diagram (3D)
Joint Variables - displacement d

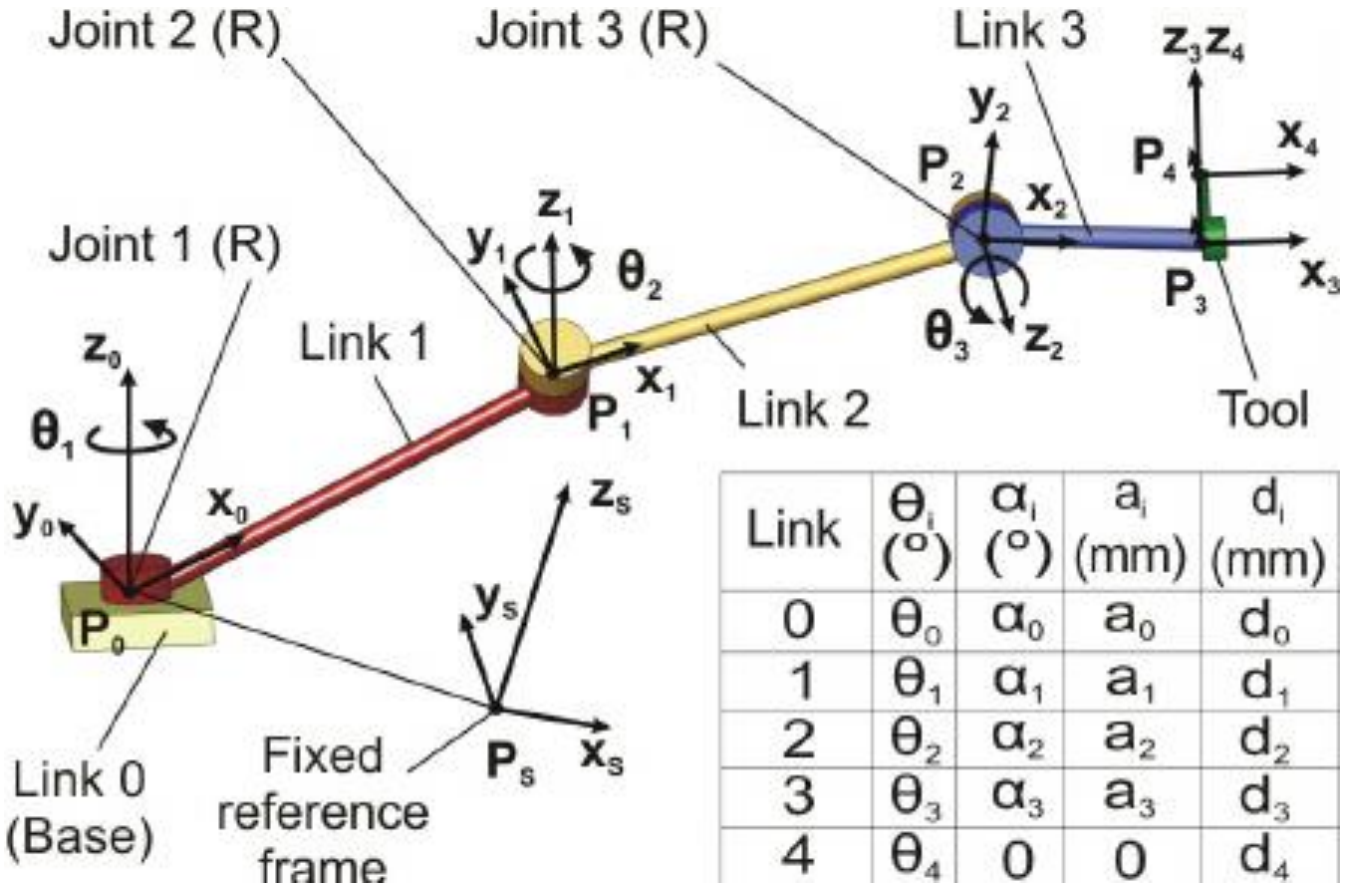


End Effector

Kinematics Diagram

SECTION 4 DENAVIT-HARTENBERG PARAMETERS

Denavit-Hartenberg Parameters



Link	θ_i (°)	α_i (°)	a_i (mm)	d_i (mm)
0	θ_0	α_0	a_0	d_0
1	θ_1	α_1	a_1	d_1
2	θ_2	α_2	a_2	d_2
3	θ_3	α_3	a_3	d_3
4	θ_4	0	0	d_4

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