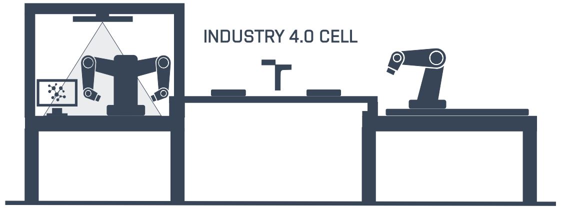
INSTITUTE OF AUTOMATION AND COMPUTER SCIENCE

Programming for robots and manipulators
Lecture 2.1

Roman Parak



NETME Centre

FACULTY OF MECHANICAL ENGINEERING institute of automation and computer science

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1. Introduction
2. Type of Joints
3. Industrial Robots
4. How to choose the right Industrial Robot?
5. Use of PLC in Robotics

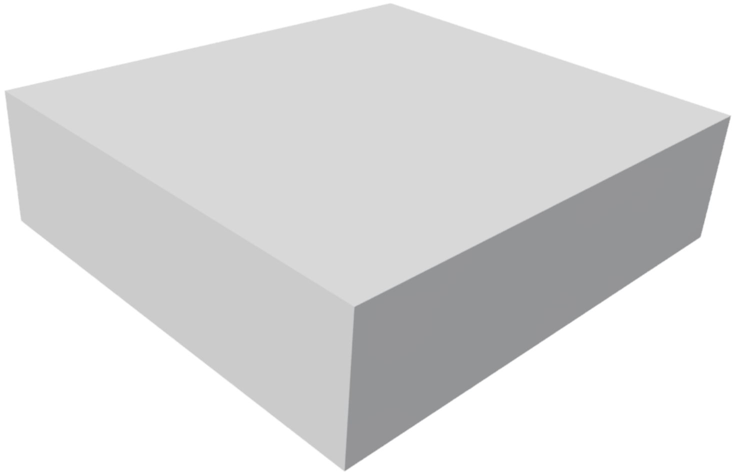
Introduction

Degree of freedom (DOF)

The degree of freedom, or DOF, is the number of independent variables (or coordinates) required to completely specify the configuration of the mechanical system.

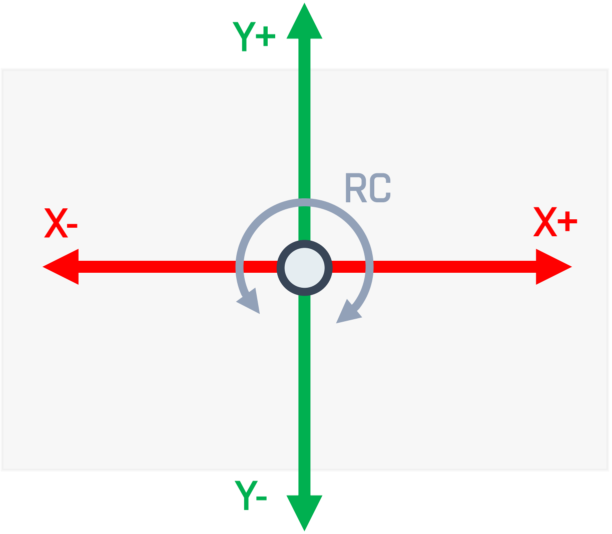
Example:

How many parameters (DoF, degrees of freedom) are needed to determine a rigid body in a 2D/3D space?



Example:

How many parameters (DoF, degrees of freedom) are needed to determine a rigid body in a 2D space?



Result:

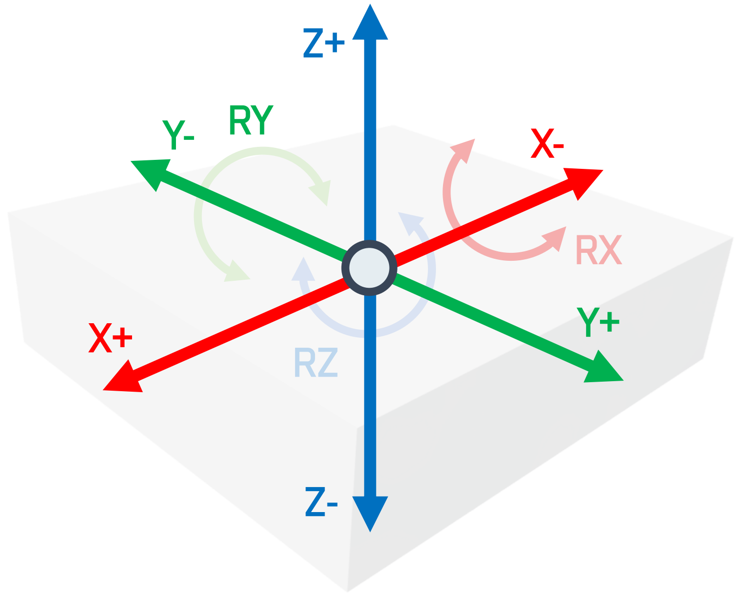
3 - (DoF, degrees of freedom)

Translation: X, Y

Rotation: RC (Centroid)

Example:

How many parameters (DoF, degrees of freedom) are needed to determine a rigid body in a 3D space?



Result:

6 - (DoF, degrees of freedom)

Translation: X, Y, Z

Rotation: RX, RY, RZ

Kinematics analyzes the geometry of a motion analytically, e.g. of a robot:

- With respect to a fixed reference co-ordinate system
- Without regard to the forces or moments that cause the motion.
- Essential concepts are position and orientation (Euler Angles, Quaternions).

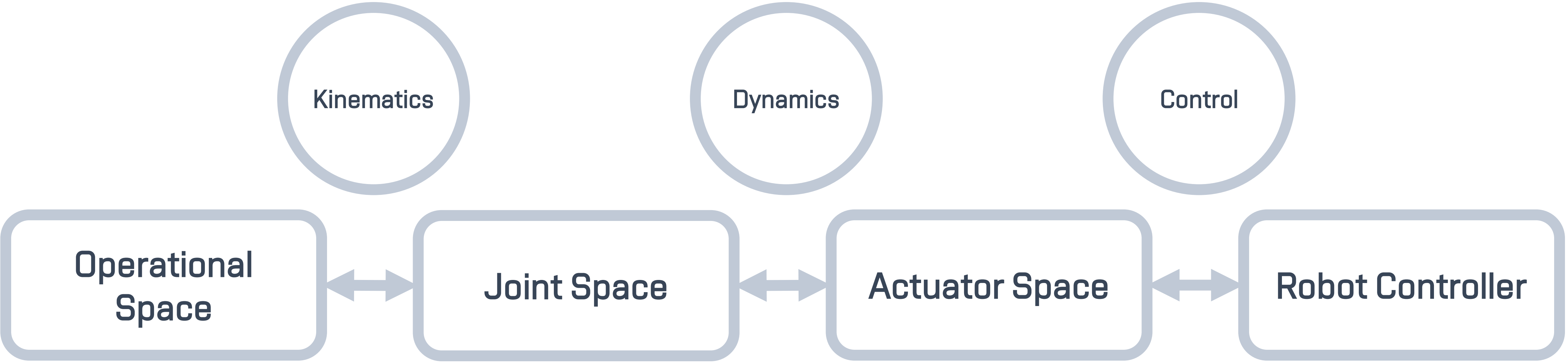
Statics deals with forces and moments applied on the mechanism, which is not moving. The essential concepts used are stiffness $[Nm^{-1}]$ and stress $[Nm^{2}]$.

Dynamics analyzes forces $[N]$ and moments $[Nm]$, which result from motion and acceleration $[ms^{-2}]$ of the mechanism and the load.

Notes:
Knowledge of the kinematic description of the robot is a prerequisite for its control and programming.
Kinematics provides knowledge of both the spatial arrangement of the robot and the reference environment.

Kinematics is only the first step to controlling a robot!

Brief Methodology of Robotics Control



Type of Joints

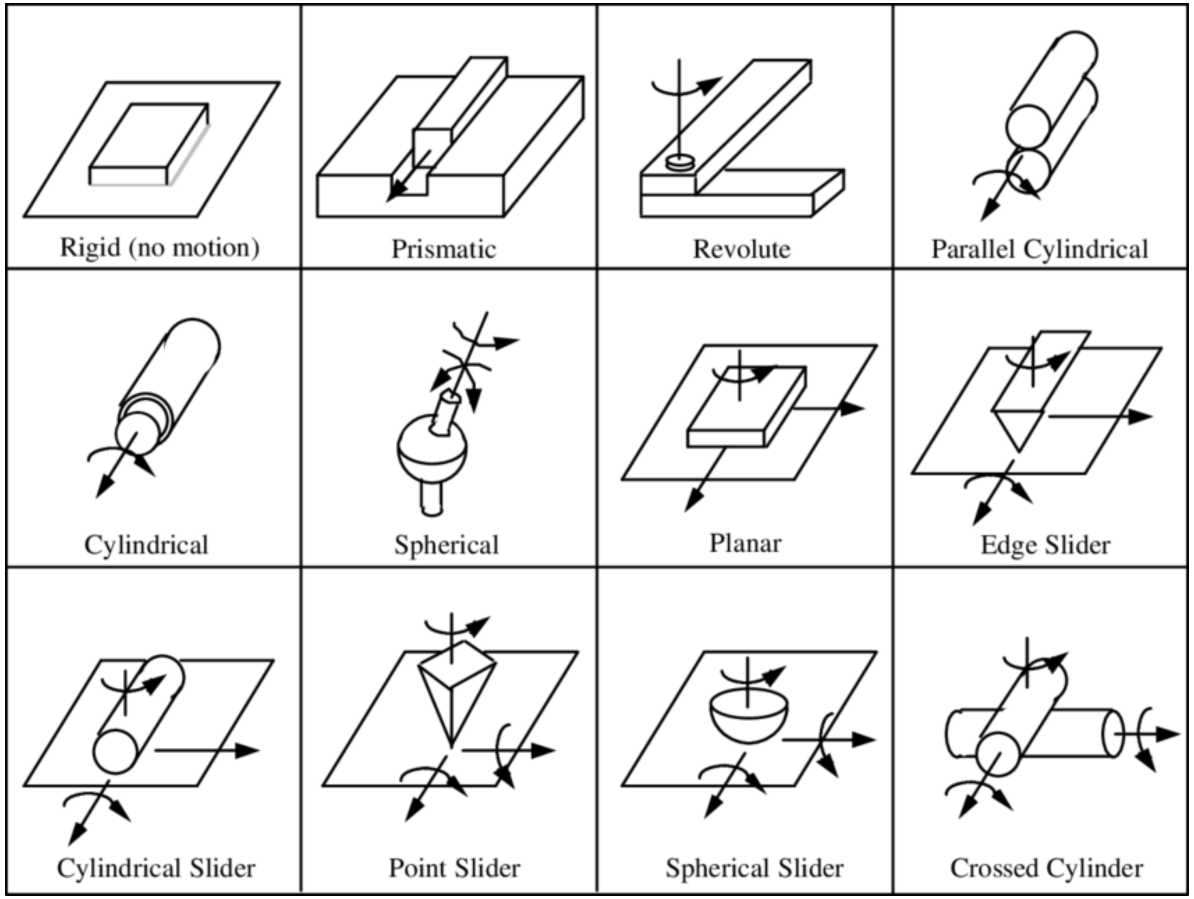
Type of Joints

Prismatic joints: have one DoF and are used to describe translational movements between objects. Their configuration is defined by one value that represents the amount of translation along their first reference frame's z-axis.

Revolute joints: have one DoF and are used to describe rotational movements (with 1 DoF) between objects. Their configuration is defined by one value that represents the amount of rotation about their first reference frame's z-axis.

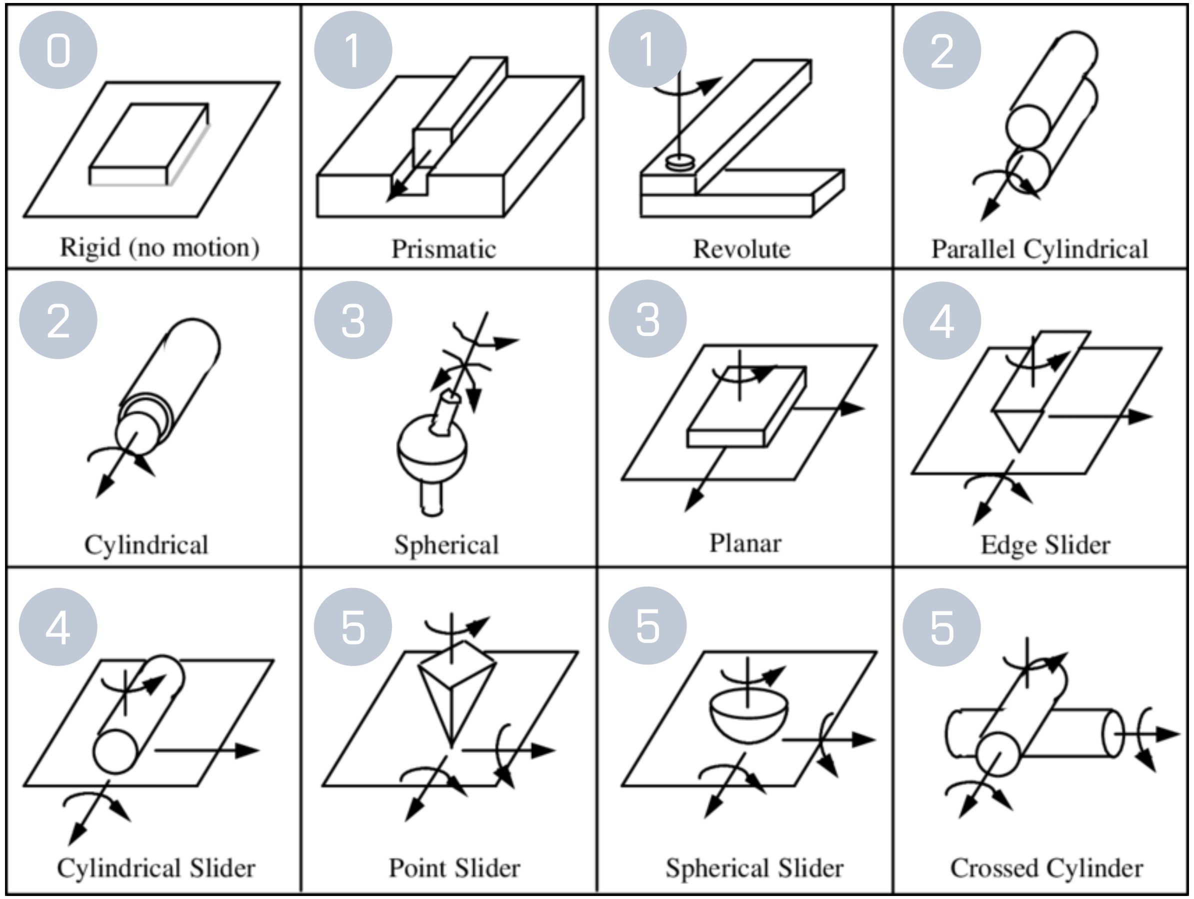
Cylindrical joint: have two DoF and provide single-axis sliding function as well as a single axis rotation, providing a way for two rigid bodies to translate and rotate freely.

Spherical joints: have three DoF and are used to describe rotational movements (with 3 DoF) between objects. Their configuration is defined by three values that represent the amount of rotation around their first reference frame's x, y and z-axis. The three values that define a spherical joint's configuration are specified as Euler angles.



[Kinematic joint types in 3-D]

Type of Joints



[Kinematic joint types in 3-D]

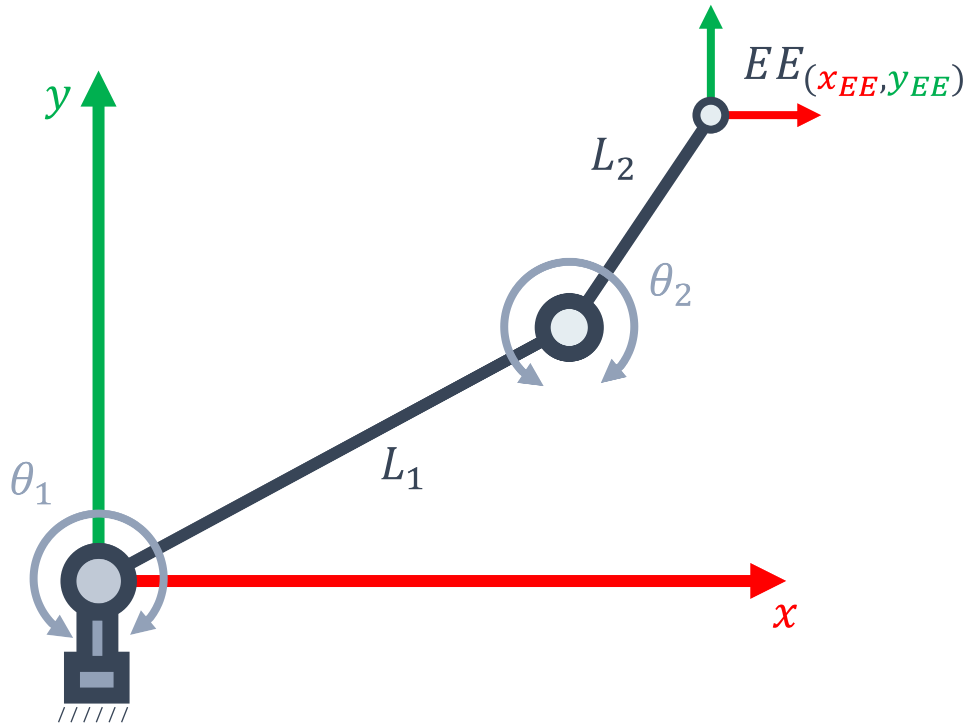
Link is the rigid part of the robot body (e.g. forearm).

Joint is a part of the robot body which allows controlled or free relative motion of two links (connection element).

End-effector is the link of the manipulator which is used to hold the tools (gripper, spray gun, etc.)

Base is the link of the manipulator, which is usually connected to the ground and is directly connected to the world coordinate system.

Kinematic pair is a pair of links, which relative motion is bounded by the joint connecting them (e.g. base and shoulder connected by J1 axis).



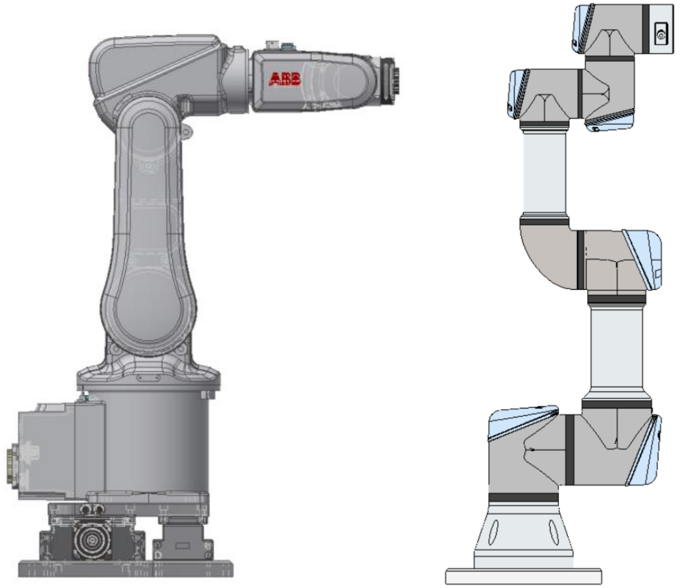
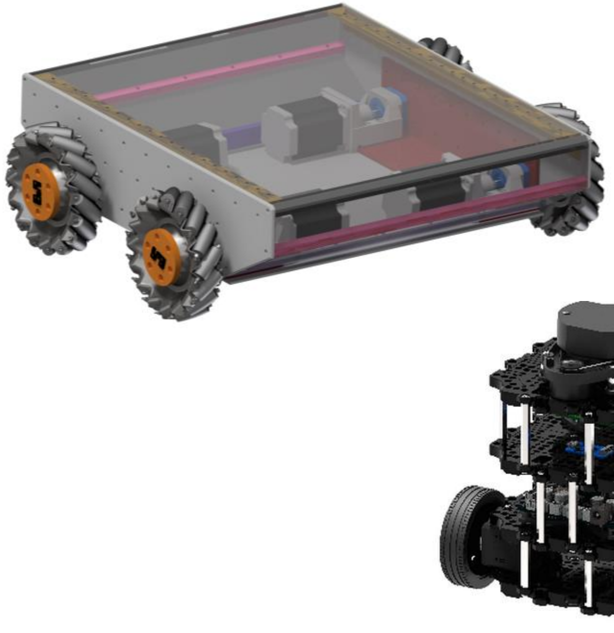
Industrial Robots

Stationary robots are those that perform their task without changing positions. The term “stationary” is more associated with the base of the robot and not the whole robot. The robot moves above the base to perform the desired operation. These robots manipulate their environment by controlling the position and orientation of an end-effector. End-effectors could be a drilling, welding, or gripper device.

Wheeled robots are vehicle-based and change their position with the help of a drive system or track system. Easy to move around, these robots operate in different environments.

Legged robots are also mobile robots, but with more complicated movement. The robots feature motorized leg appendages to control their locomotion, allowing them to perform effectively on uneven ground. These robots tend to cost more, though, due to their complexity.

Other robots:
Animal-based, Swarm, Augmenting robots and Flying Robots (Drones).

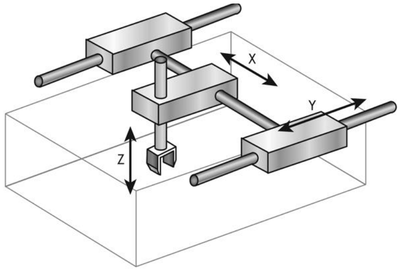
Stationary Robots	Wheeled Robots	Legged Robots
		

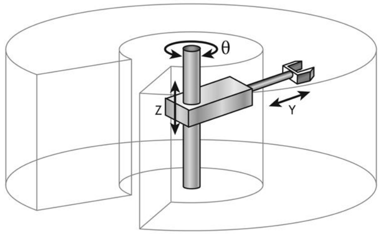
Stationary Robots

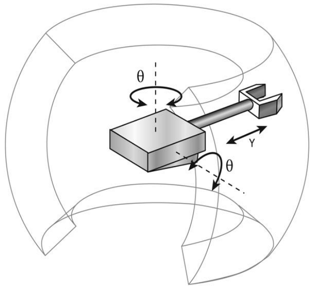
Most industrial robots are classified as stationary robots with a robotic arm moving above a stationary base.

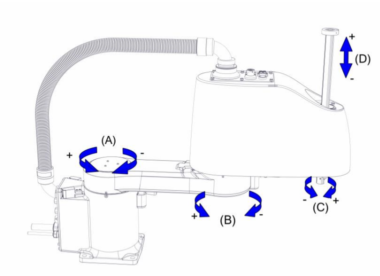
Stationary robots can be divided into six main types:

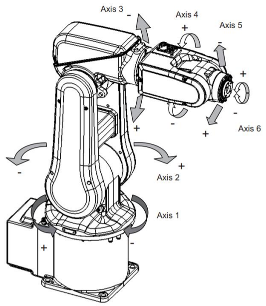
- Cartesian/Gantry
- Cylindrical
- Spherical
- SCARA
- Articulated
- Parallel

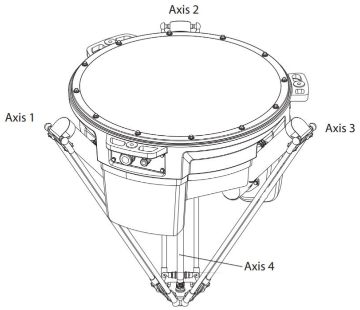










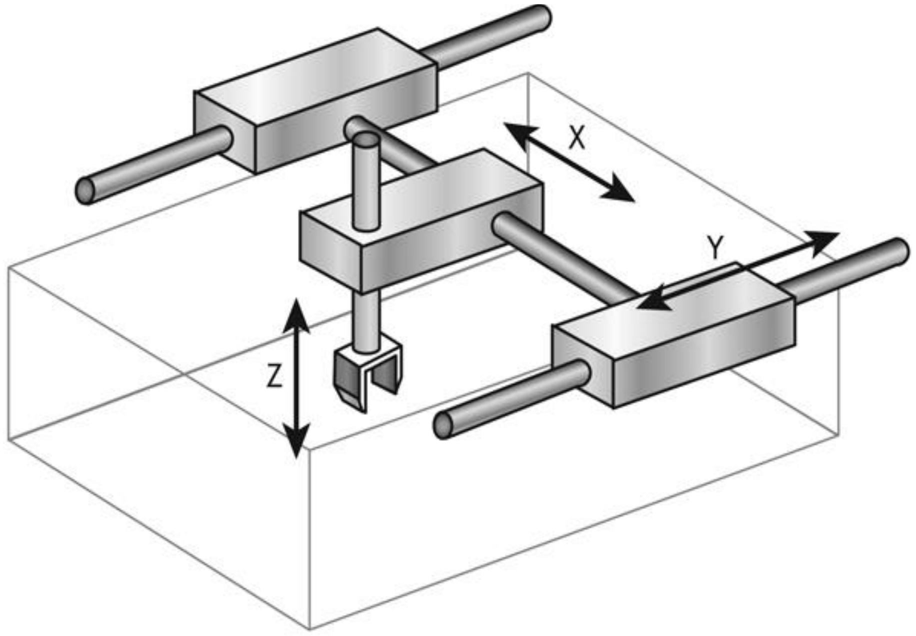


Cartesian/Gantry Robots

A Cartesian robot operates in the X, Y, and Z-axes to reach its end position.

Cartesian, or gantry robots (also known as rectilinear robots) have three linear joints that use the Cartesian coordinate system. They operate within the x-, y-, and z-axis by using linear guide rails. These guide rails help translate the end-effector into the correct position by moving each linear guide rail in the corresponding axis.

These robots are typically used for pick-and-place work, application of sealant, assembly operations, or handling machine tools, and arc welding.



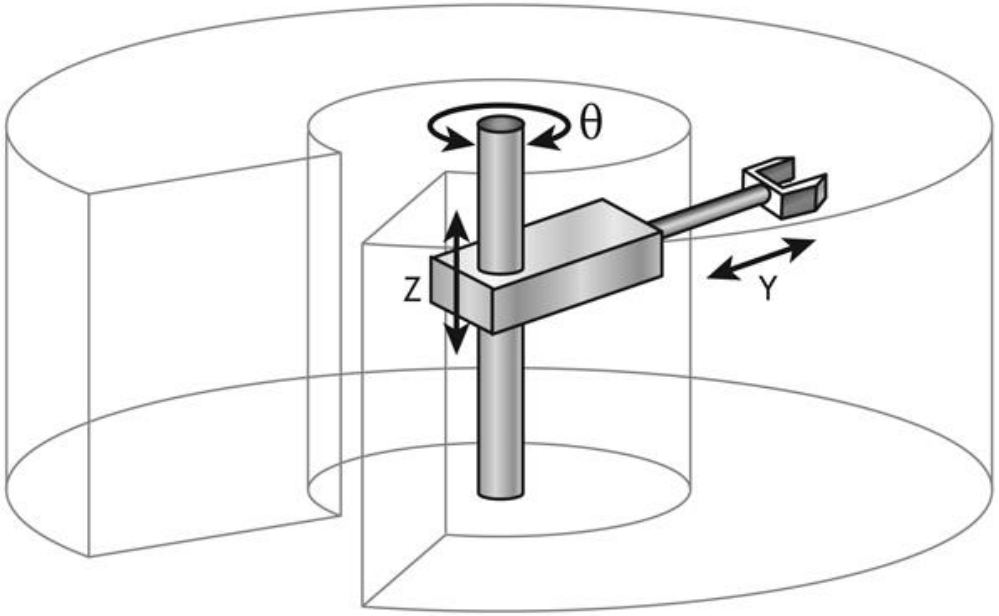
Cartesian Robot

Cylindrical Robots

The cylindrical robot has a rotary joint along the joint axis for rotation movement and a prismatic joint for linear motion.

A cylindrical robot has at least one rotary joint at the base and at least one prismatic joint to connect the links. Along the joint axis, the rotary joint uses a rotational motion; along the prismatic joint, it moves in a linear motion. Their movements occur within a cylindrical-shaped work envelope.

Cylindrical robots are used for assembly operations, handling of machine tools and die-cast machines, and spot welding.

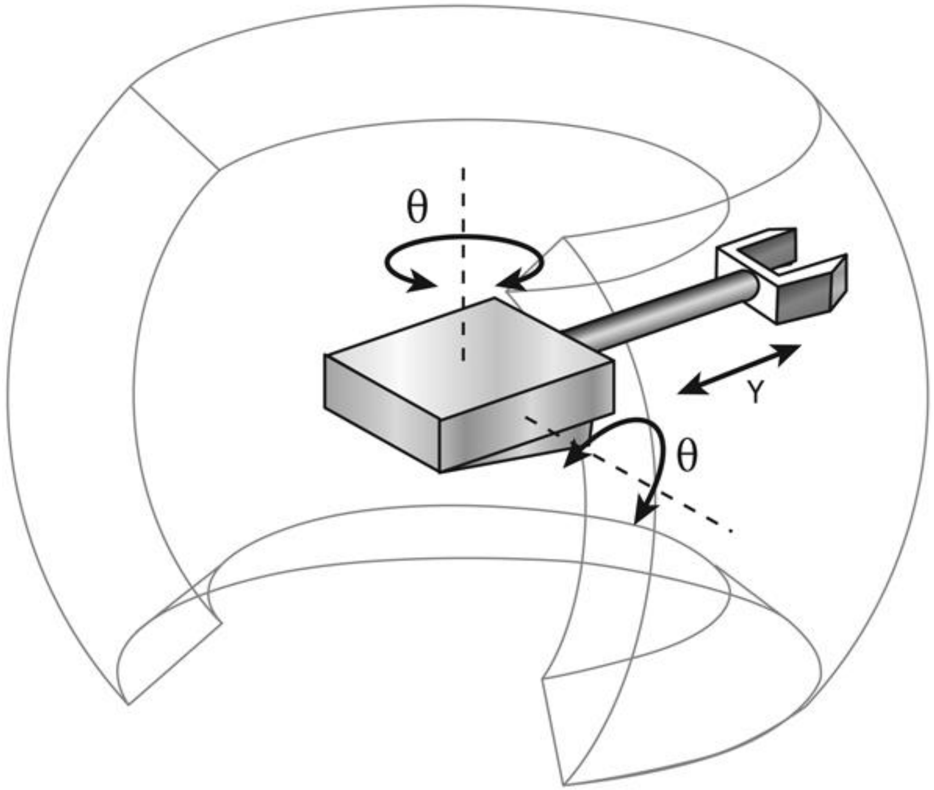


Cylindrical Robot

With its combined rotational joint, two rotary joints, and a linear joint, the spherical robot operates in the polar coordinate system to achieve a spherical-shaped work envelope.

These are also known as polar robots. The arm is connected to the base with a twisting joint and has a combination of two rotary joints and one linear joint. The axes of the combined joints form a polar coordinate system and operate within a spherical-shaped work envelope.

These robots are used for the handling of machine tools, spot welding, die casting, fettling machines, and gas and arc welding.

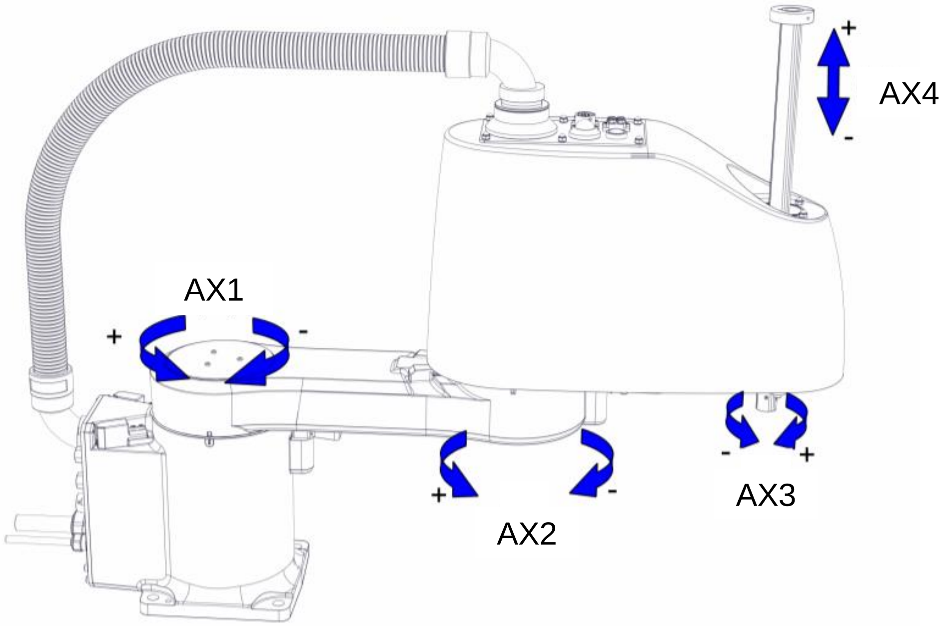


Spherical Robot

A SCARA robot is mainly used in assembly applications due to the nature of its movement, such as jobs that require drilling or tapping assemblies.

SCARA robots are primarily used for assembly applications. The compliant arm, which is cylindrical in design, is comprised of two parallel joints that provide it with compliance in one selected plane.

These robots are used for pick-and-place work, application of sealants, assembly operations, and handling of machine tools.



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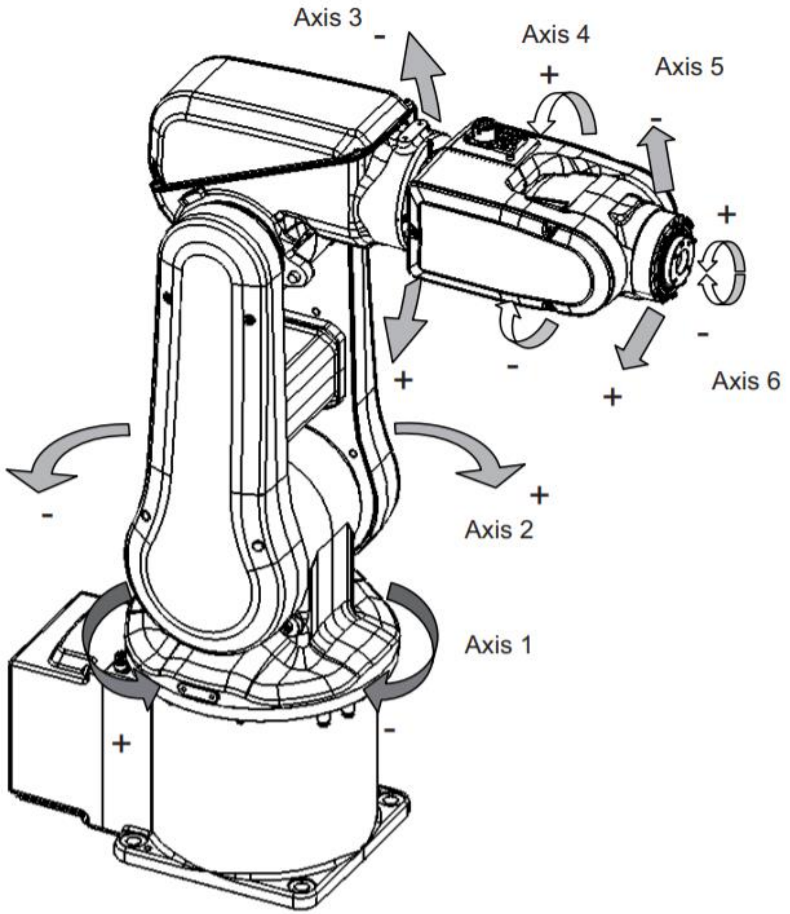
Articulated Robots

Robotic arms are some of the most common robots used in manufacturing today. They are essential to assembly operations that require heavy lifting or dangerous movements.

Robotic arms, or articulated robots, feature rotary joints that can range from a simple two-joint structure to a complicated structure with 10 or more joints. The arm is connected to a base that has a twisting joint. Rotary joints connect the links in the arm, each joint is a different axis and provides an additional degree of freedom. Industrial robotic arms have four or six/seven axes.

Such robots are primarily used for assembly operations, arc welding, and painting.



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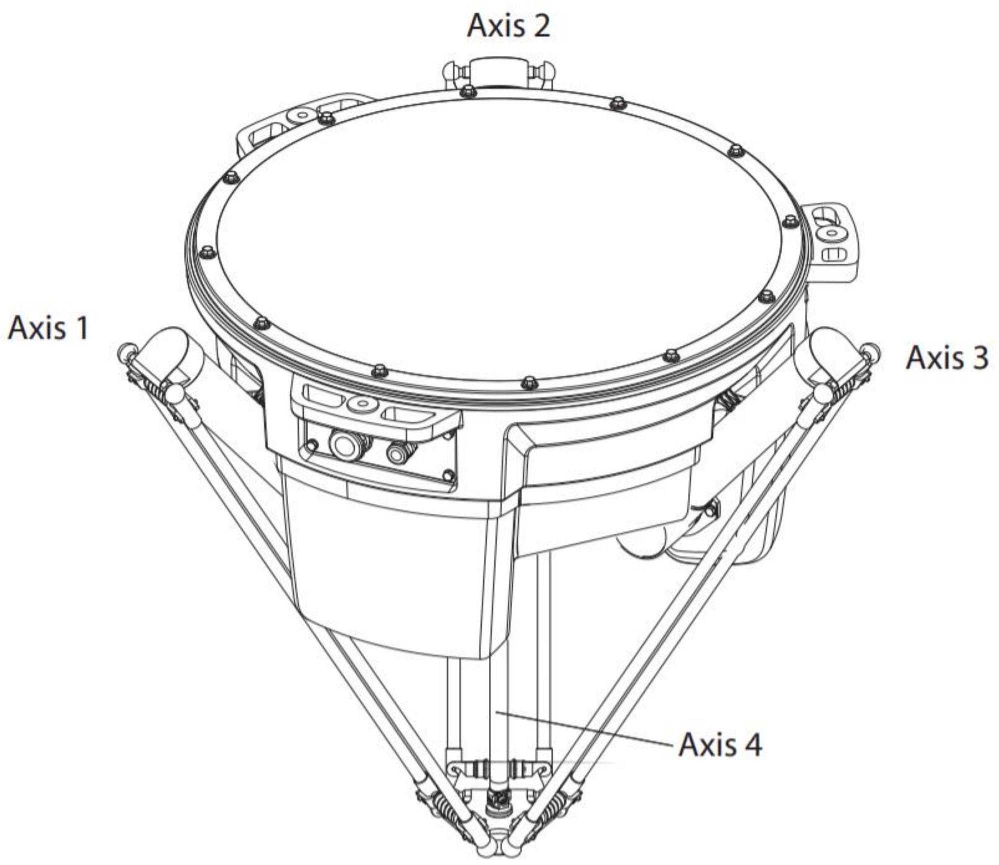
Parallel or delta robots are used often in pick-and-place operations such as drug and food sorting.

Parallel robots are also known as delta robots. They are built from jointed parallelograms connected to a common base. The parallelograms move a single end of arm tooling in a dome-shaped envelope.

They are used primarily in the food, pharmaceutical, and electronics industries. The robot itself is capable of precise movement, making it ideal for pick-and-place operations.



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How to choose the right Industrial Robot?

How to choose the right Industrial Robot?

Industrial robot and single-purpose manipulator?

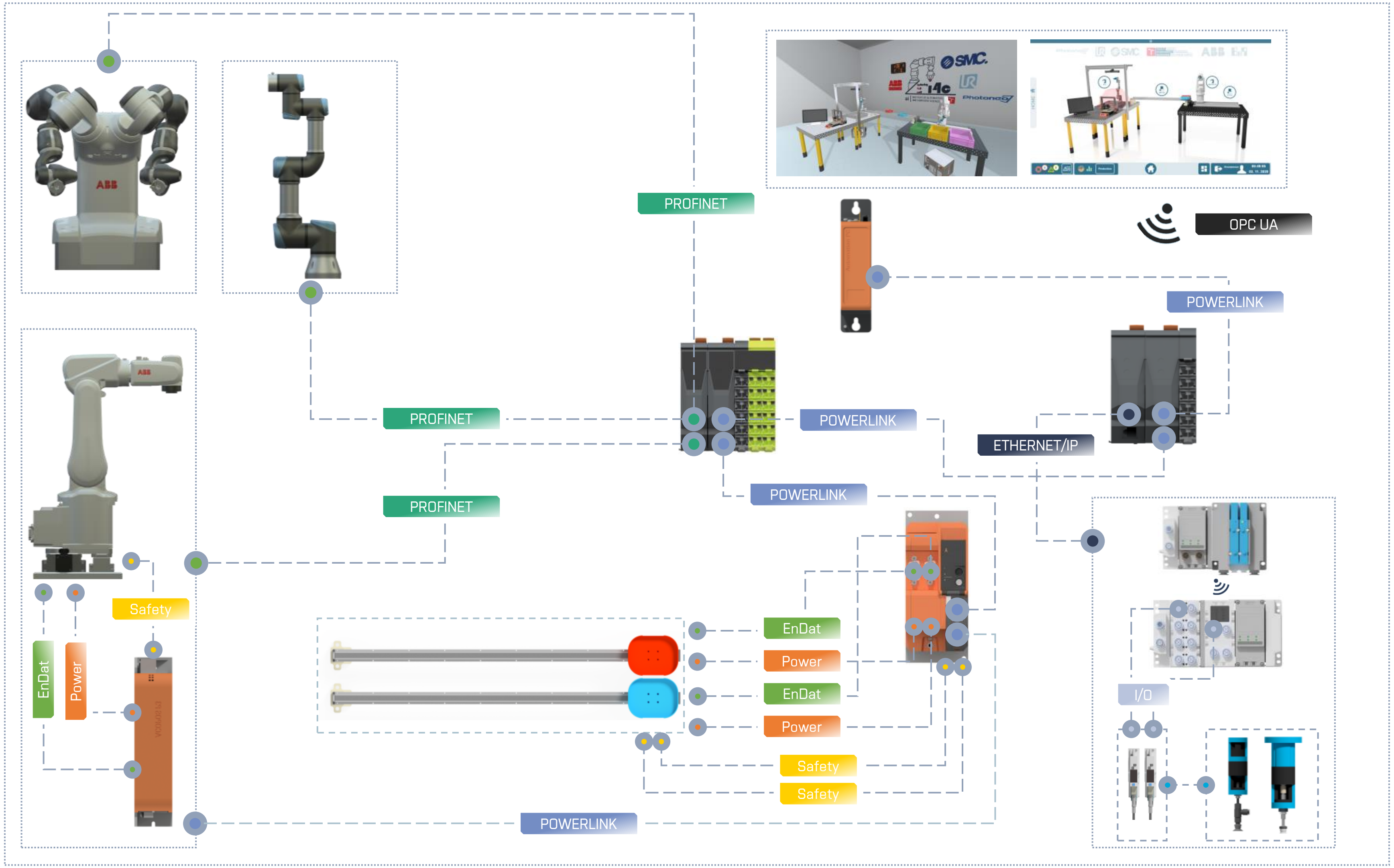
Type of Application?

Parameters (Robot mass, Payload, Reach - Operating Range, Speed, Repeatability/Accuracy, Brake and Moment of Inertia, Protection level(IP))?

Price?

Use of PLC in Robotics

Use of PLC in Robotics



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Thank You!

Questions?

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