

Robotics & Automation (ELL406)

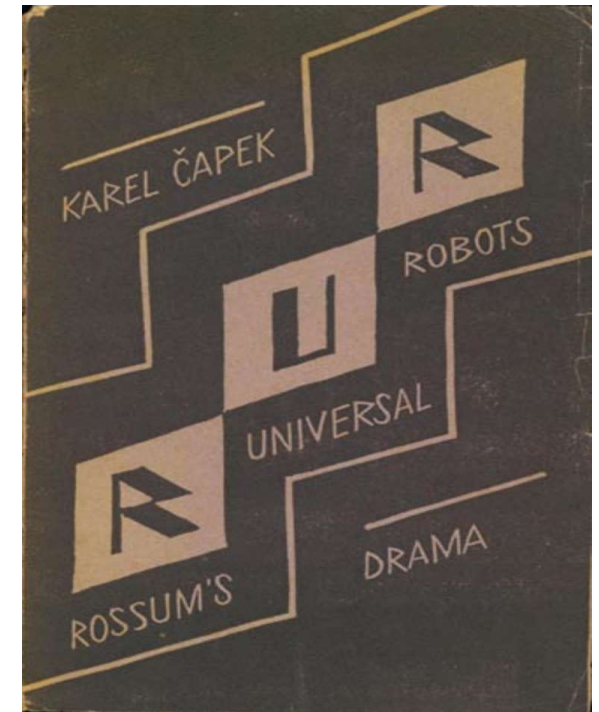
Instructor: Subashish Datta
Department of Electrical Engineering
IIT Delhi

Overall Syllabus

- Introduction
- Rigid Motion
- Robot Kinematics
- Path & Trajectory Planning
- Robot Dynamics
- Robot Control



Czech play writer:
Karel Čapek

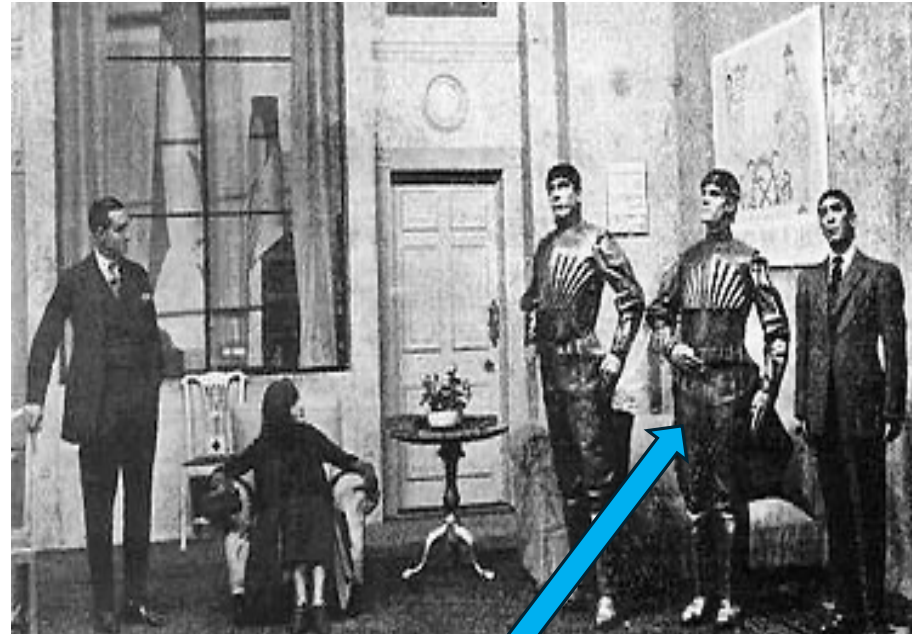


A science fiction play:
Rossum's Universal Robots
(R.U.R.) in 1920.



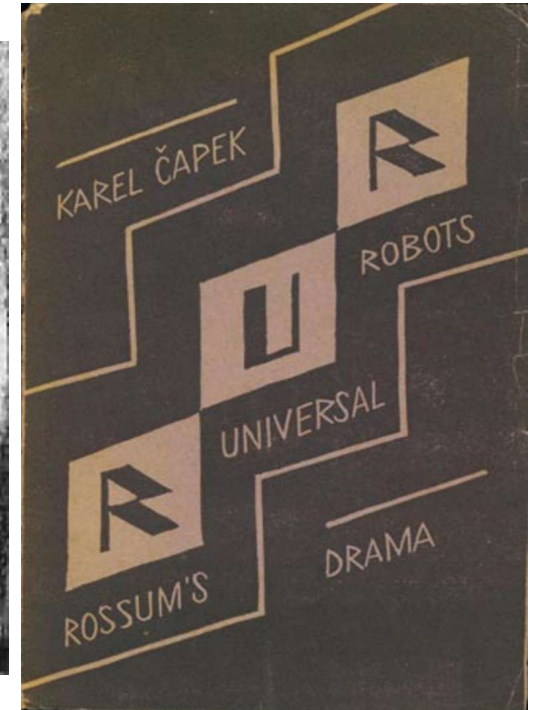
Czech play writer:
Karel Čapek

*Source: Wikipedia



Three ROBOTS

The General Manager of R.U.R.,
telling the history of the factory to Helena....



A science fiction play:
Rossum's Universal Robots
in 1920.

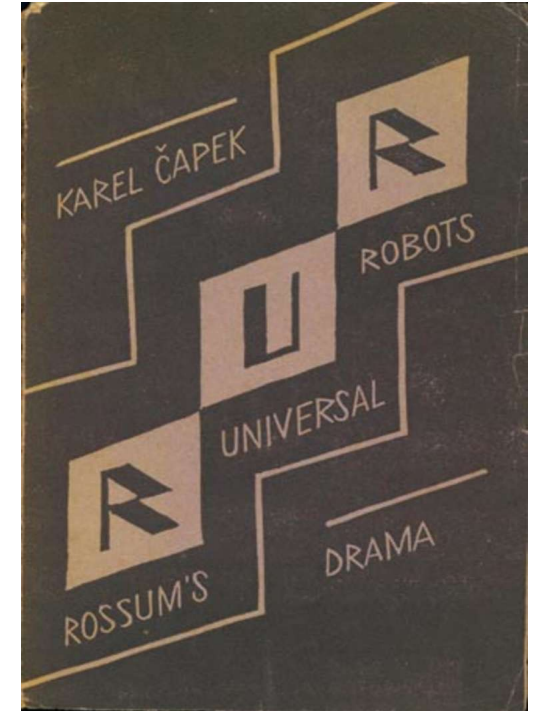
a factory that makes *artificial workers*
from synthetic organic matter



Czech play writer:
Karel Čapek

*Source: Wikipedia

*Rossum had come to the island in 1920 to study marine biology. In 1932, Rossum had invented a substance like organic matter, though with a different chemical composition. Rossum's uncle argued with him about their motivations for creating artificial life. While the elder wanted to create animals to prove or disprove the existence of God, his nephew only wanted to become rich. Young Rossum finally locked away his uncle in a lab to play with the monstrosities he had created and created thousands of **robots**.



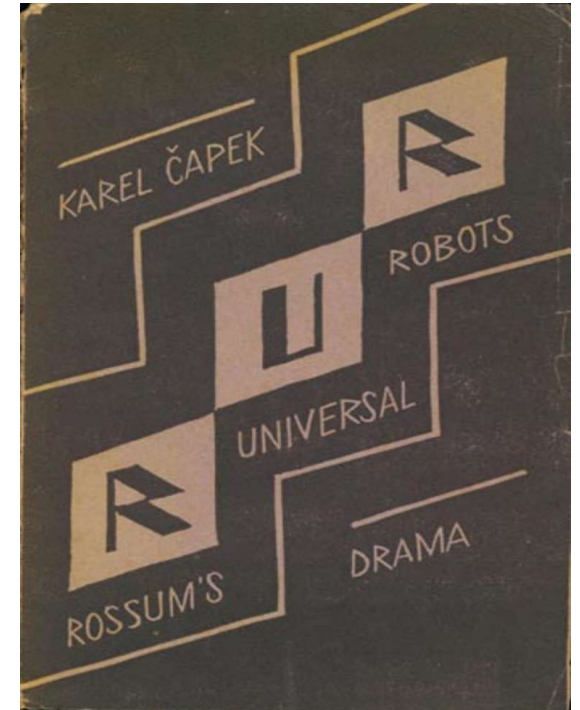
A science fiction play:
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a factory that makes **artificial workers**
from synthetic organic material



Czech play writer:
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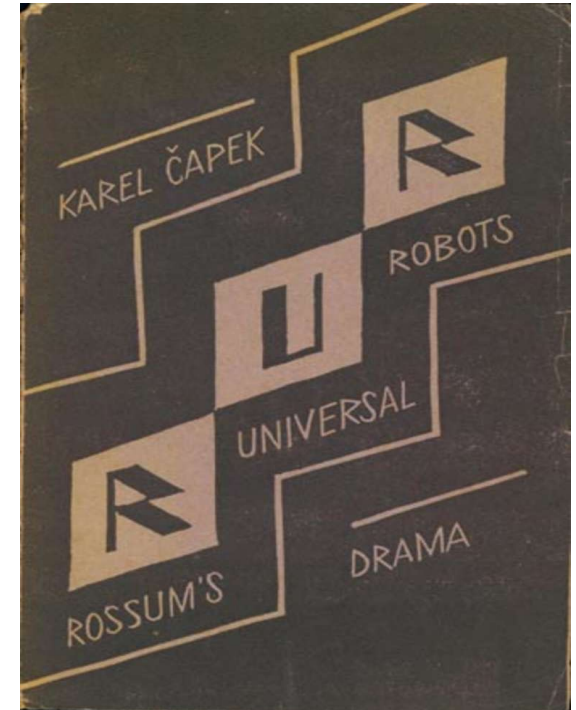
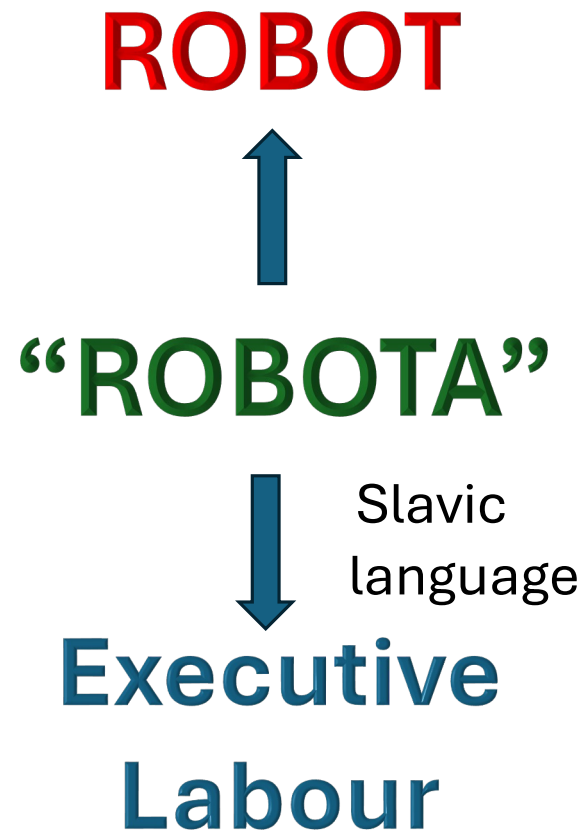
ROBOT
↑
“ROBOTA”



A science fiction play:
Rossum's Universal Robots
(R.U.R.) in 1920.



Czech play writer:
Karel Čapek



A science fiction play:
Rossum's Universal Robots
(R.U.R.) in 1920.



Isaac Asimov

Professor in Biochemistry
and Science fiction writer

- Considered robot as an *automation of human appearance, without feelings...*
- Its brain is programmed by a human being in such a way that it *satisfy certain rules of ethical conduct.*

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given by human beings, except when such orders would conflict with the first law.
3. A robot must protect its own existence, as long as such protection does not conflict with the first or second law.

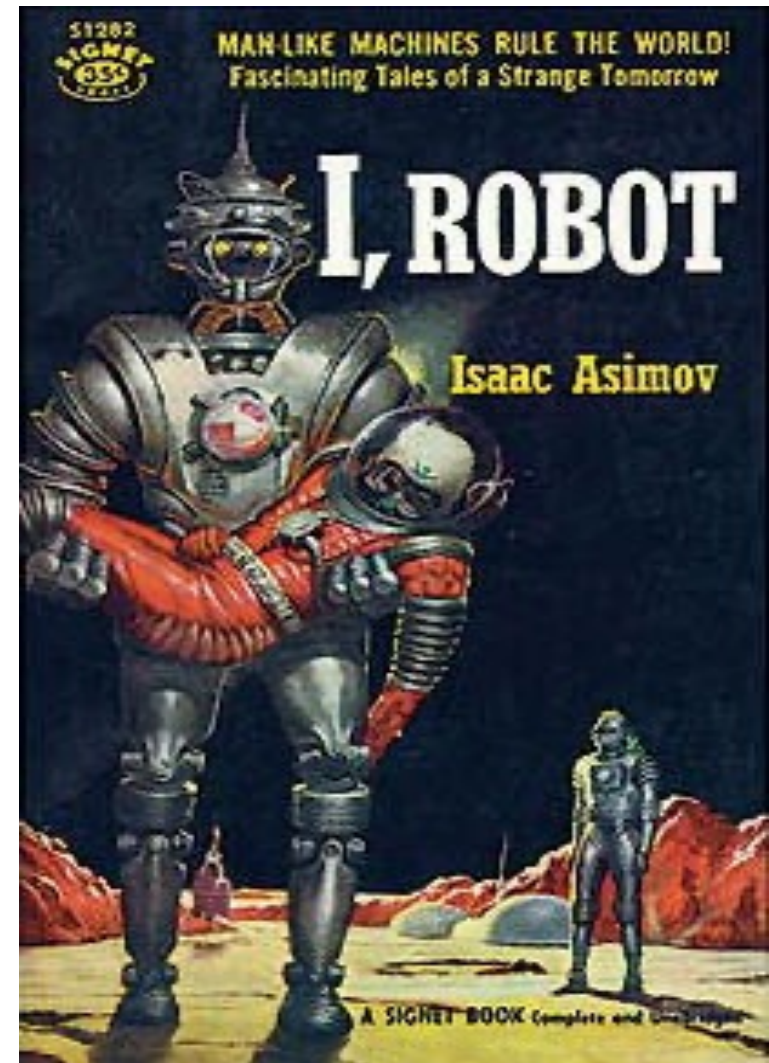
Consider as specifications for the design of a robot



Isaac Asimov

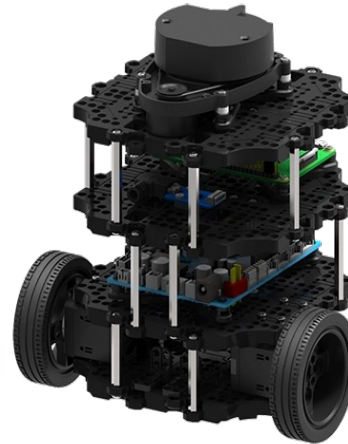
Professor in Biochemistry
and Science fiction writer

A first robot
obeying all
three ethical
laws...



For us, Robot is not the way Rossum had thought of !

It is an *electro-mechanical complex system, satisfying Asimov's three laws....*





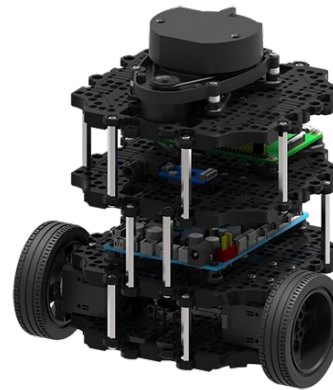
Fixed base robot
(manipulators)

Types of robots based on its mechanical structure:

- Fixed base robot (manipulators)
- Mobile robots
- Flying robots



Mobile robot



Mobile robot



Flying robot

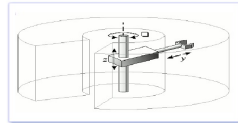
All Types of Robots by Locomotion

STATIONARY ROBOTS

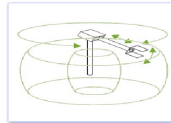
Cartesian Robots



Cylindrical



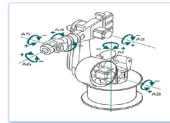
Spherical



SCARA



Articulated

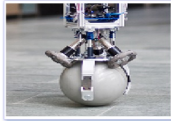


Parallel

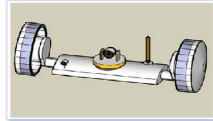


WHEELED ROBOTS

Single Wheel



2 Wheeled



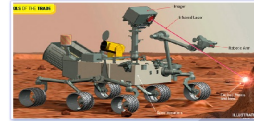
3 Wheeled



4 Wheeled



6 Wheeled



Tracked Robots



LEGGED ROBOTS

One Leg



Bipedal



Tripedal



Quadrupedal



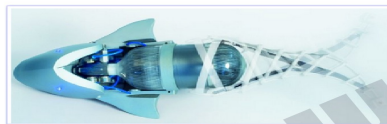
Hexapod



Many Legs



SWIMMING ROBOTS



FLYING ROBOTS



Robotic Balls



SWARM ROBOTS



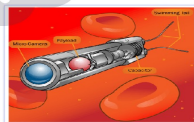
MODULAR ROBOTS



MICRO Robots



NANO Robots



SOFT ROBOTS



SNAKE Robots



CRAWLER Robots



HYBRID Robots



www.robotpark.com

Robotpark

In this course we will focus mainly on

Fixed-base robots: Robotic Manipulator

Robot Manipulator

Consists of a sequence of **rigid bodies (links)** interconnected by means of **joints...**



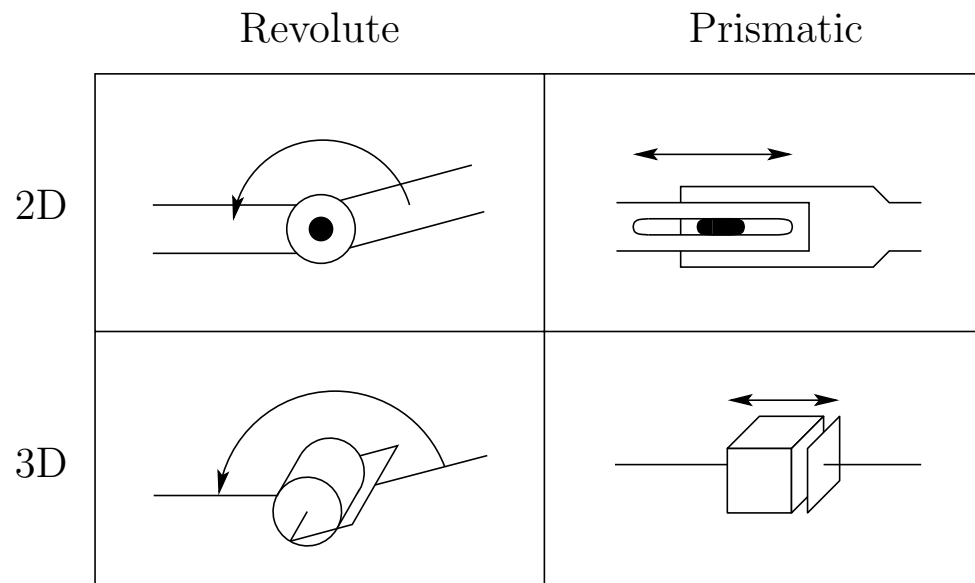
End-effector (performs the task)

Links

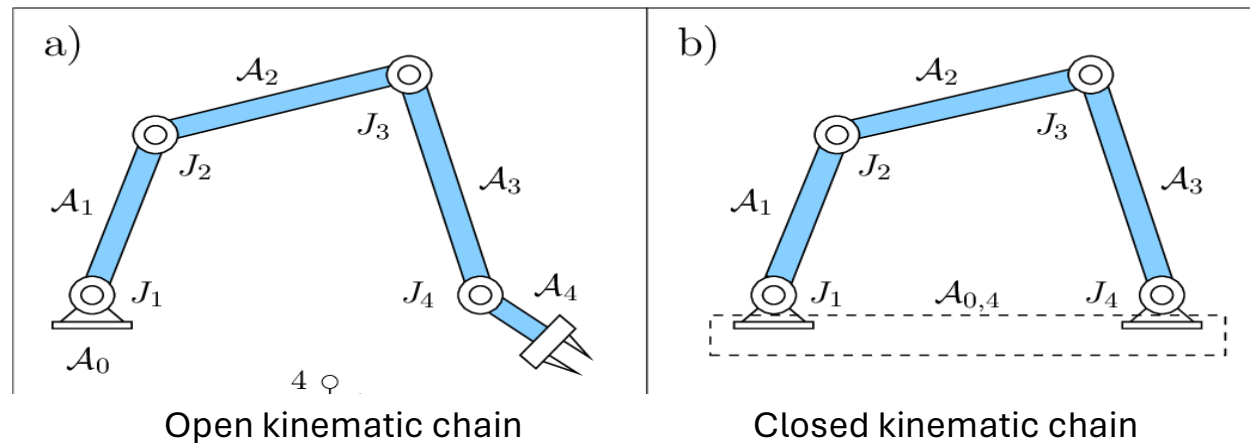
Joint

Base

- Joints are typically *rotary (revolute)* or *linear (prismatic)*.
- A *revolute joint* creates a relative *rotational motion* between the two links
- A *prismatic joint* allows a relative *translational motion* between the two links

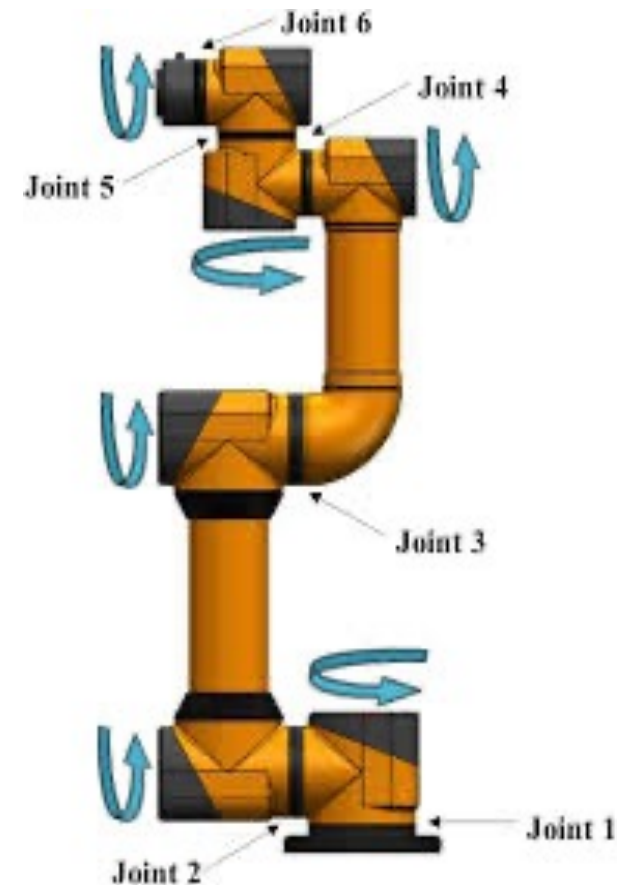
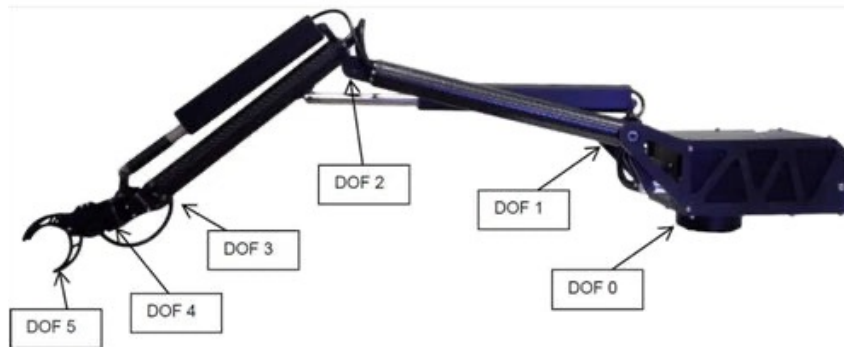


- Robot Manipulators are composed of links connected through joints to form a *kinematic chain*. The kinematic chain could be open or closed.
- *Open kinematic chain*: there is only one sequence of links connecting the two ends of the chain
- *Closed kinematic chain*: a sequence of links forms a loop



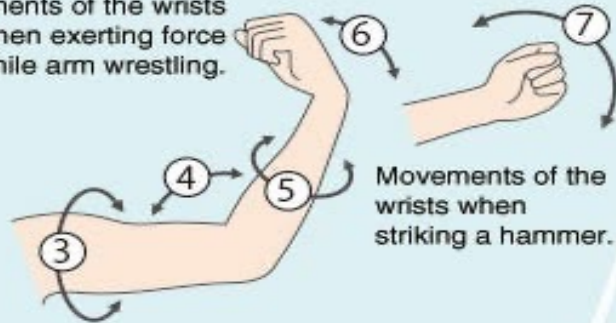
Degree of Freedom (DOF)

- In an open kinematic chain, *each prismatic or revolute joint provides the structure with a single DOF*.
- In a closed kinematic chain, *the number of DOFs is less than the number of joints* in view of the constraints imposed by the loop.

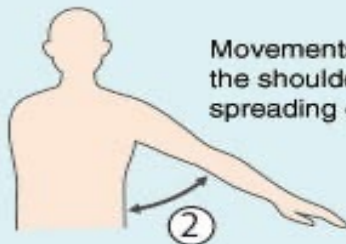


Degree-of-freedom of a human arm

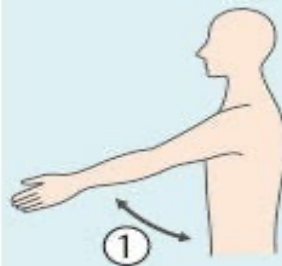
Movements of the wrists when exerting force while arm wrestling.



Movements of the wrists when striking a hammer.



Movements of the shoulders when spreading out the arms.



Movements of the shoulders to swing the arms while walking.

Figure 1

Degree-of-freedom of the arms of a robot

wrist **T**urning
Wrist Turning

wrist **B**ending
Wrist Bending
(bending of the wrist)

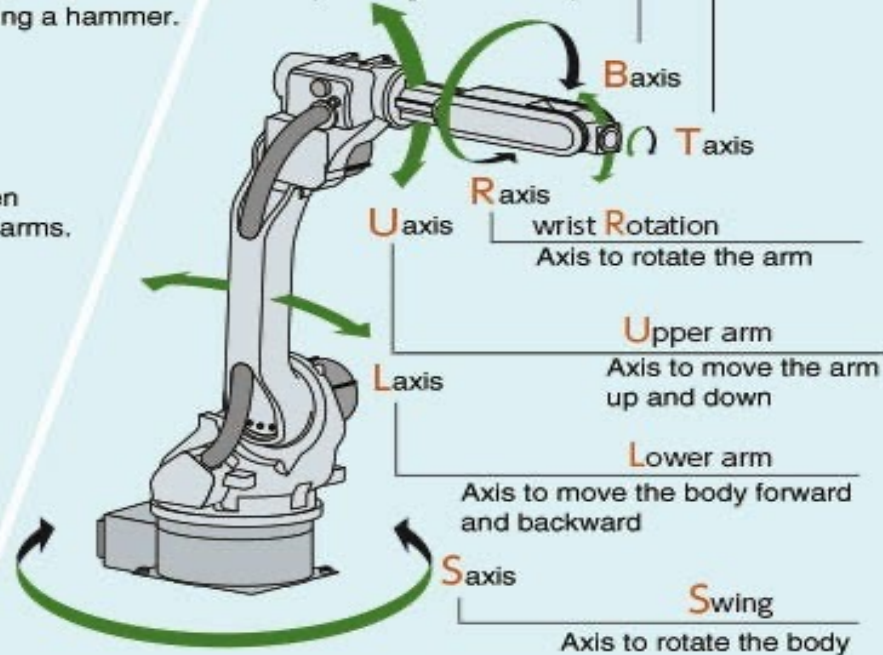


Figure 2

- Consider the task of arbitrarily positioning and orienting an object



- Consider the task of *arbitrarily positioning and orienting* an object



Six DOFs are required:
3 for position and 3 for orientation



- Consider the task of arbitrarily positioning and orienting an object



Six DOFs are required:
3 for position and 3 for orientation



A manipulator should have at least 6-DOFs.

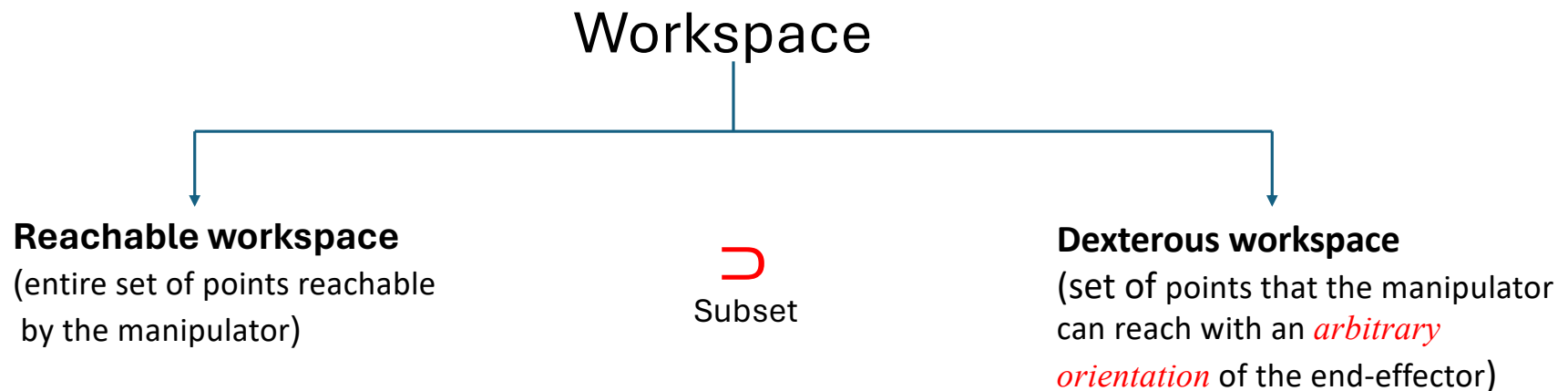


If less than 6-DOFs then the manipulator cannot reach to every point in its work-environment. If it has more than 6-DOFs, then it is referred to as *kinematically redundant manipulator*.



Workspace

- The *workspace* represents the portion of the environment that a manipulator's end-effector can access. Its shape and volume depend on the manipulator structure as well as on the presence of mechanical joint limits.

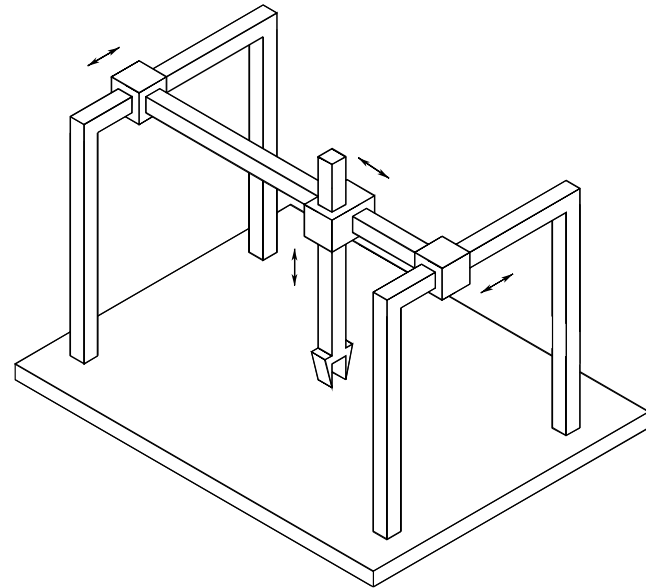
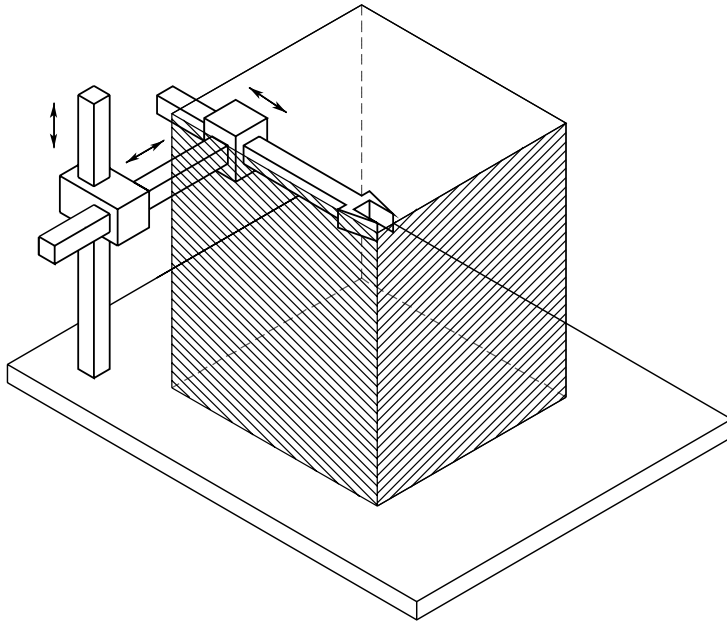


Classification of Robotic Manipulators (w.r.t. Geometry or kinematic structure)

- Cartesian,
- Cylindrical,
- Spherical,
- SCARA,
- Anthropomorphic (Articulated or revolute)

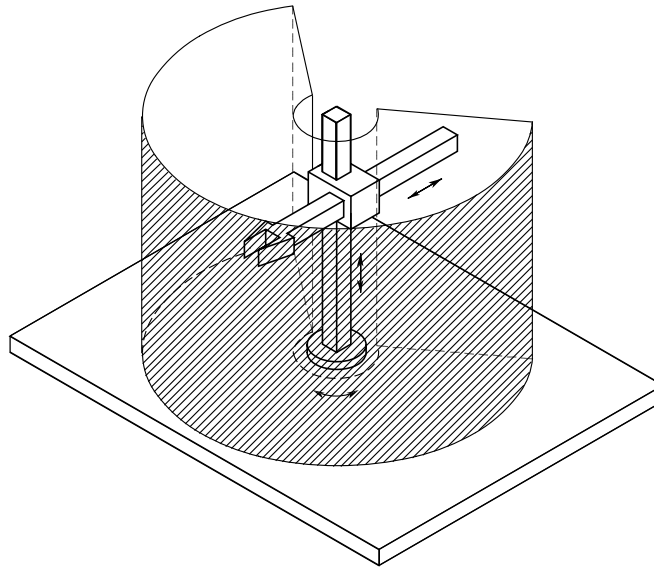
Cartesian

- Cartesian geometry is realized by *three prismatic joints whose axes typically are mutually orthogonal*.



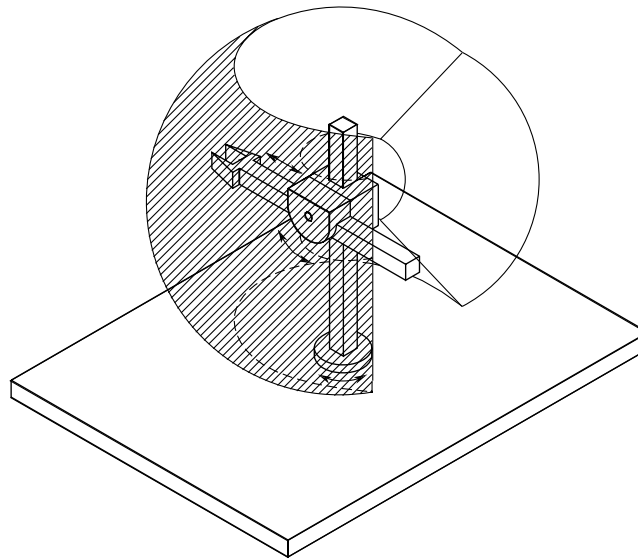
Cylindrical

- The *first joint is revolute* and produces a rotation about the base, while the *second and third joints are prismatic*.



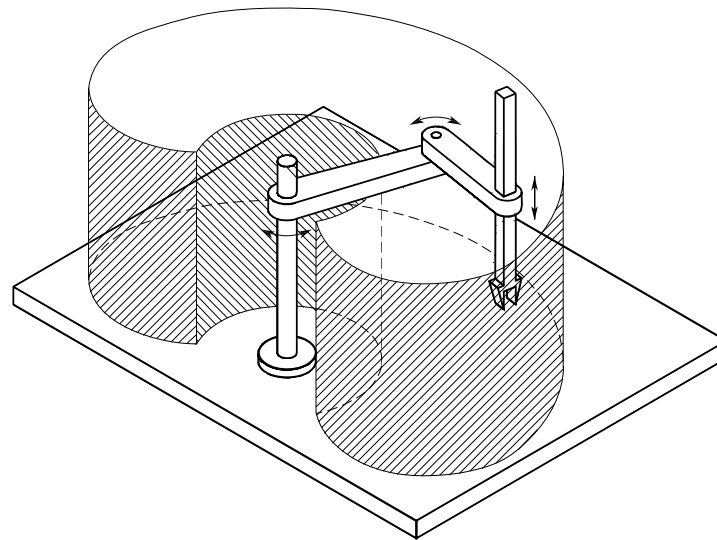
Spherical

- Spherical geometry differs from cylindrical where the *second prismatic joint is replaced with a revolute joint*.



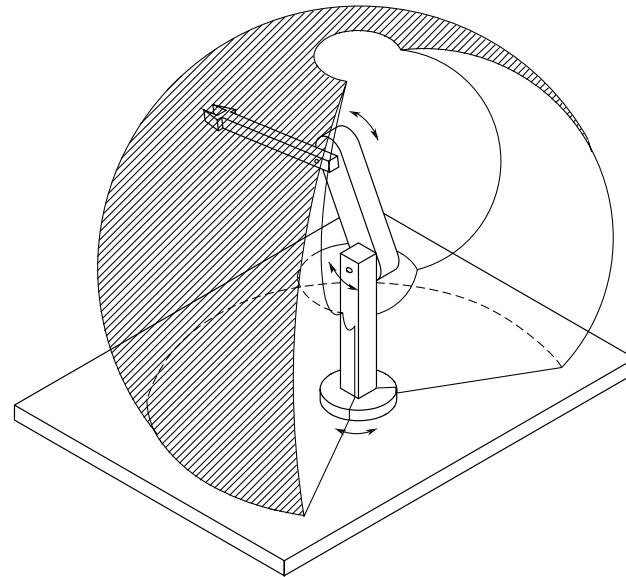
SCARA (Selective Compliance Assembly Robot Arm)

- It has *two revolute joints and one prismatic joint* geometrically arranged in such a way that *all the axes of motion are parallel*.



Anthropomorphic (Articulated or revolute)

- Anthropomorphic geometry is realized by *three revolute joints*; the *revolute axis of the first joint is orthogonal to the axes of the other two which are parallel*.
- The anthropomorphic structure is the most dexterous one, since all the joints are revolute.

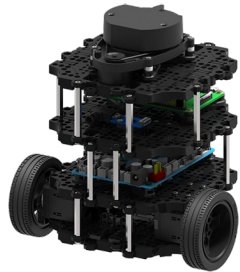


Mobile Robots

- Mobile robots has a *mobile base* which allows the robot to move freely in the environment.

Mobile Robots

Wheeled



Legged

