# Lecture Notes on Robotics

## Course Code (M1596)

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Lecture 02: Robotics classifications and applications.


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Before we proceed, let us make it clear that this classification is very broad, and we will not cover all robot types under it. Also, some types of classifications may overlap. For example, an industrial robot can be classified as a Cartesian robot as well. Or an airborne drone can also be classified as a defence robot.

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These characteristics are typical of second generation robots which is the subject of this course.

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is used in a applications such as Arc Welding, Spot Welding Material Handling Machine Tending and so on.

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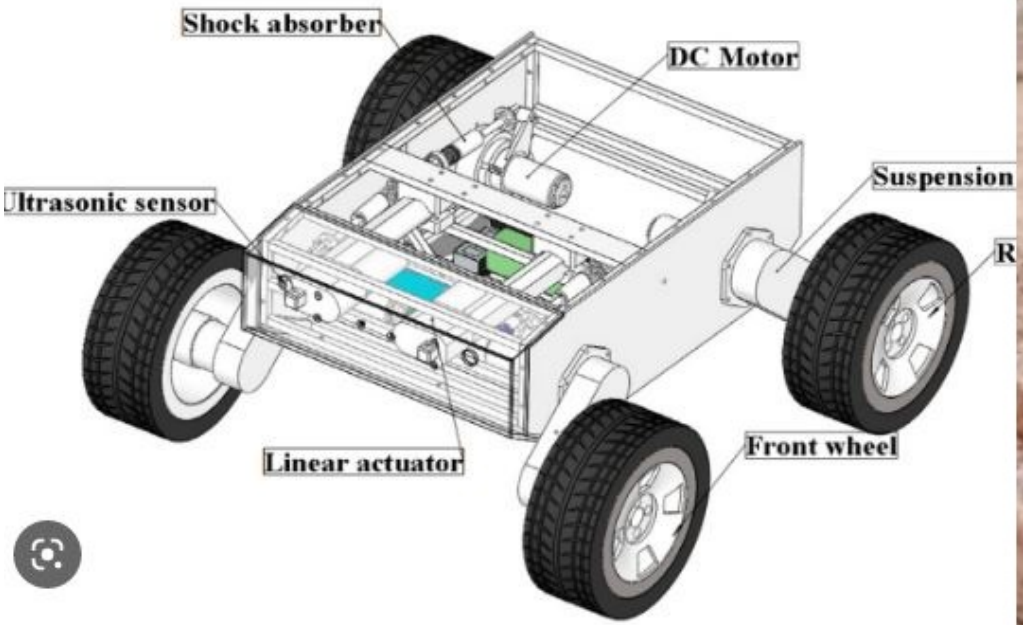


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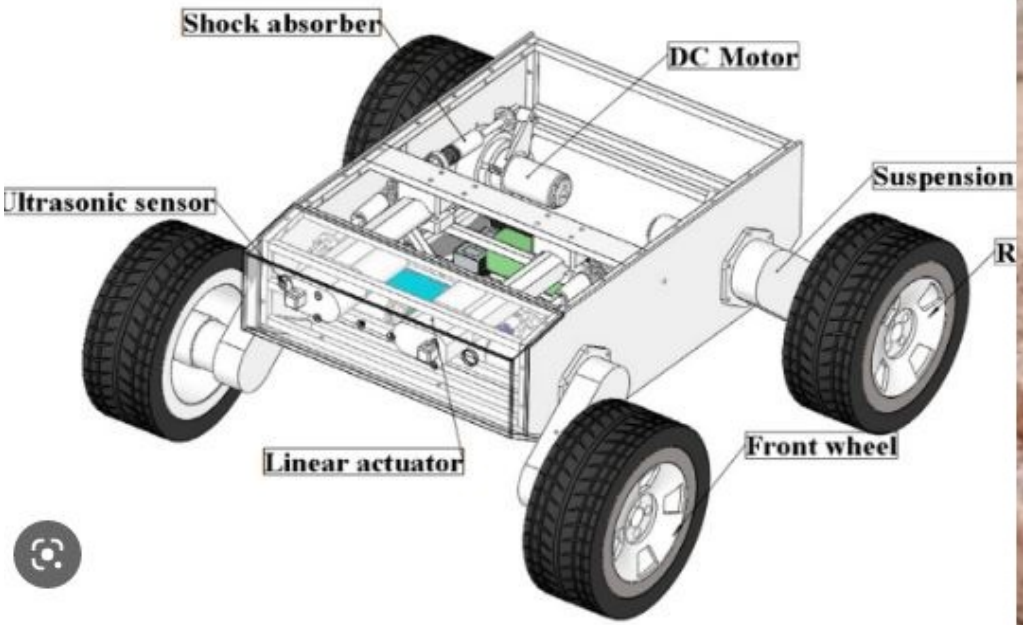


Legged robots are a type of mobile robot which use articulated limbs, such as leg mechanisms, to provide locomotion.

## Classifications of Robots Depending on Robot Base (Legged)

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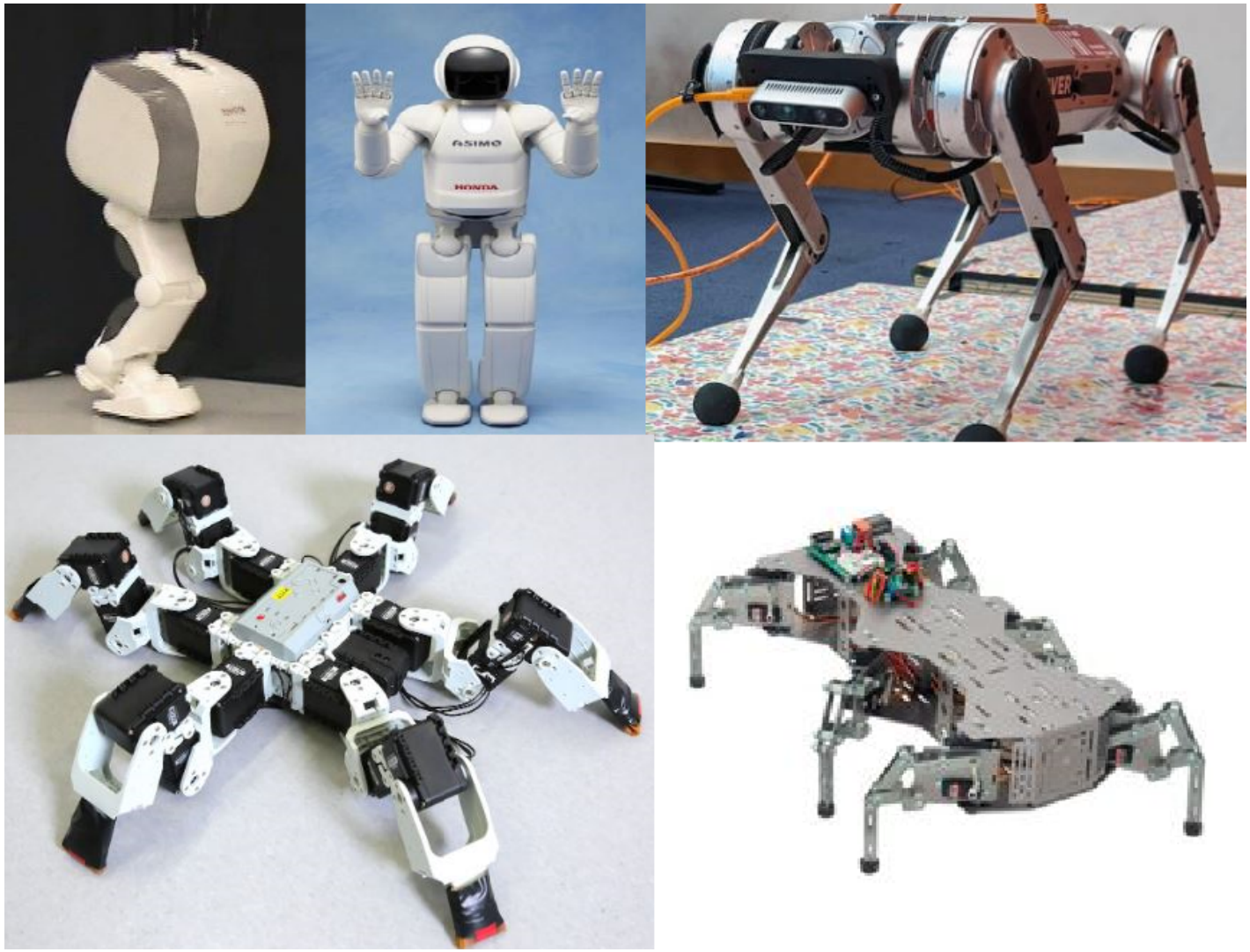

# Classifications of robots

**Classifications of Robots Based on Kinematics of mechanical structure.**

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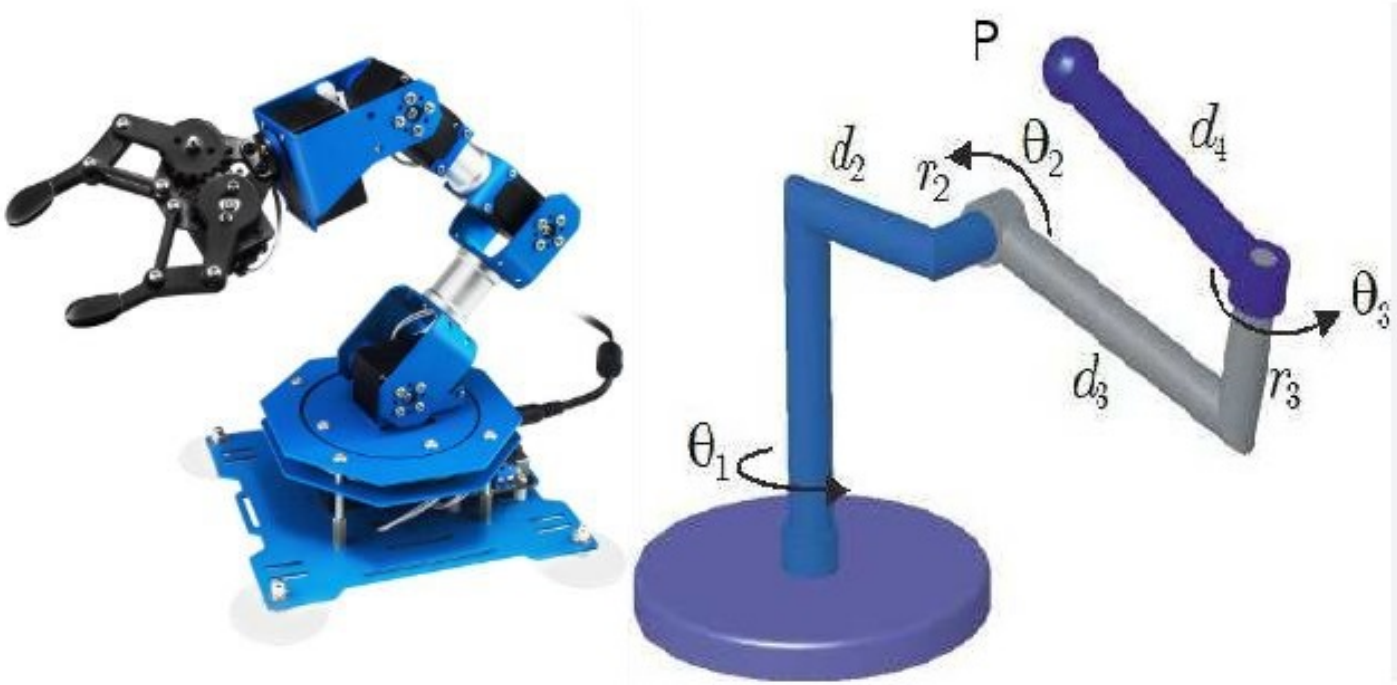
Serial robots or manipulators that takes structure of an open loop chain are the most common industrial robots and they are designed as a series of links connected by motor-actuated joints that extend from a base to an end-effector.



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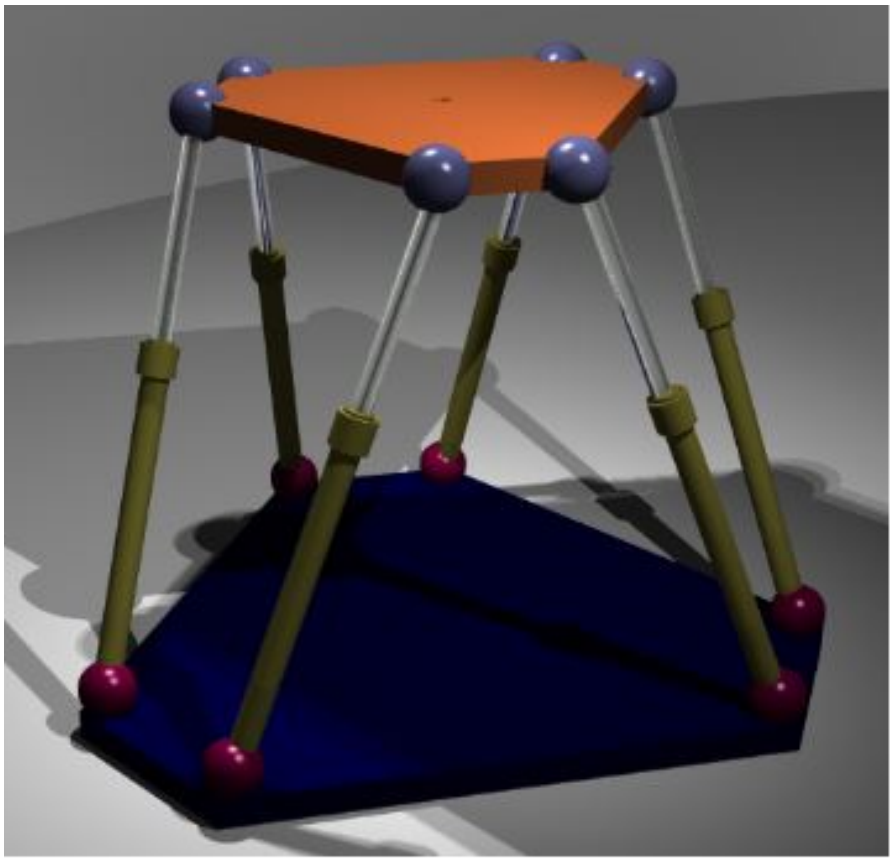
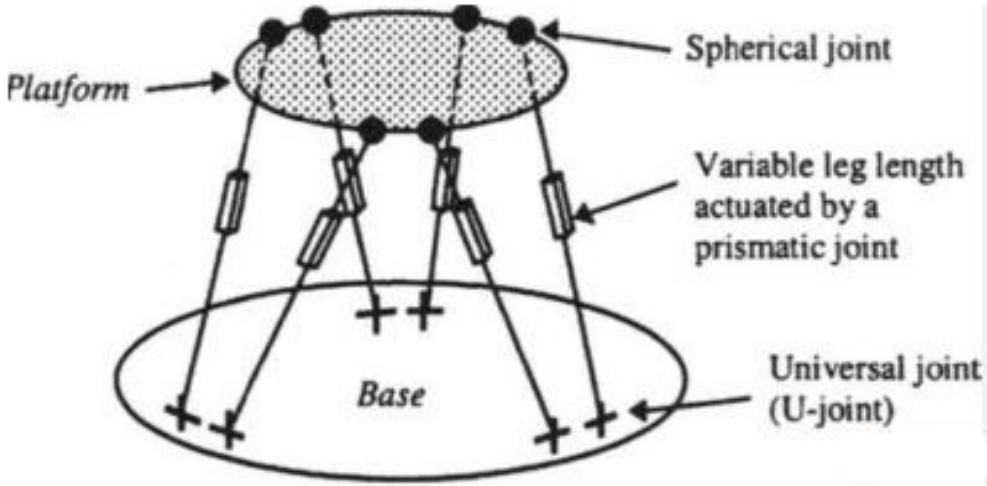
a parallel manipulator consists of a closed-loop chain, and hybrid manipulator if it is consists of both open and closed-loop chains.





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They are known as Micro manipulators mounted on the end effector of larger but slower serial manipulators

- Examples of parallel robot contain serial and parallel links.

Picking and Placing

Assembly

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**Common applications include:**
Component insertion, Spot welding, Hole drilling, Machine loading and unloading and Assembly operations.

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**2. Continuous-path (CP) control robot**

The CP robot is capable of performing movements along the controlled path. With CP from one control, the robot can stop at any specified point along the control path. All the points along the path must be stored explicitly in the robot's control memory. Applications Straight-line motion is the simplest example for this type of robot.

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**3. Controlled-path robot**

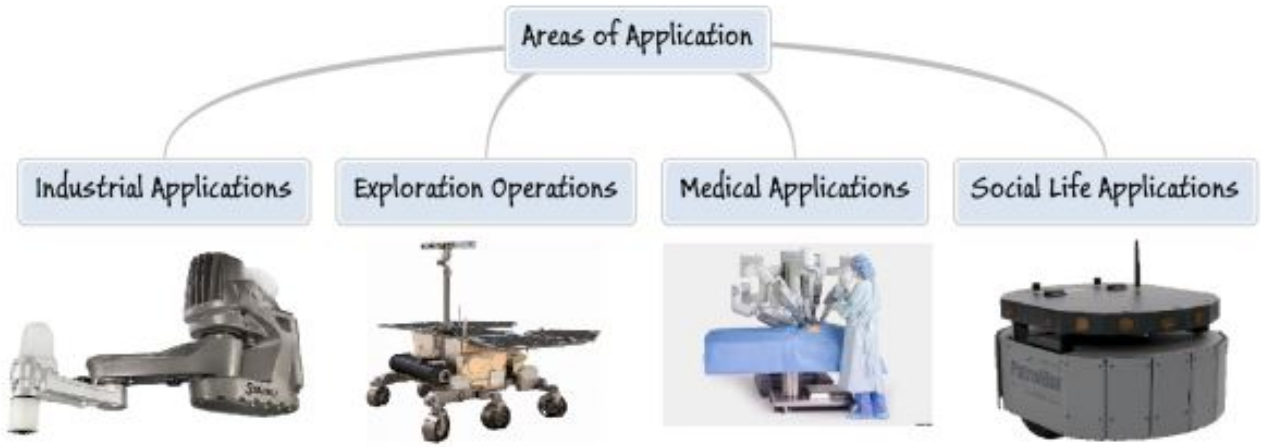
In controlled-path robots, the control equipment can generate paths of different geometry such as straight lines, circles, and interpolated curves with a high degree of accuracy. Good accuracy can be obtained at any point along the specified path an controlled-path robots have a servo capability to correct their path.

Robotic Fish by University of Essex, UK
http://www.bmt.org/News/?/3/0/510
Other examples from MIT, USA
http://web.mit.edu/towtank/www/Pike/pike.html

**mechenggs.blogspot.in**

# Classifications of robots

**Classifications of Robots based on applications.**
One of the most popular way of classifying robots – and one of the simplest – is by what they actually do. Based on this classification, there are four broad ways of categorising robots.




There are four main areas in which robots can be used. These are industrial, exploration, medical, and social applications

# Classifications of robots

## Industrial applications

- Industrial applications:There are certain general economical and practical conditions in an industrial situation that may require the installation of robots, such as hazardous or uncomfortable working conditions, repetitive tasks, difficult handling, and multi-shift

Handling for metal casting

Palletizing


Packaging

# Classifications of robots

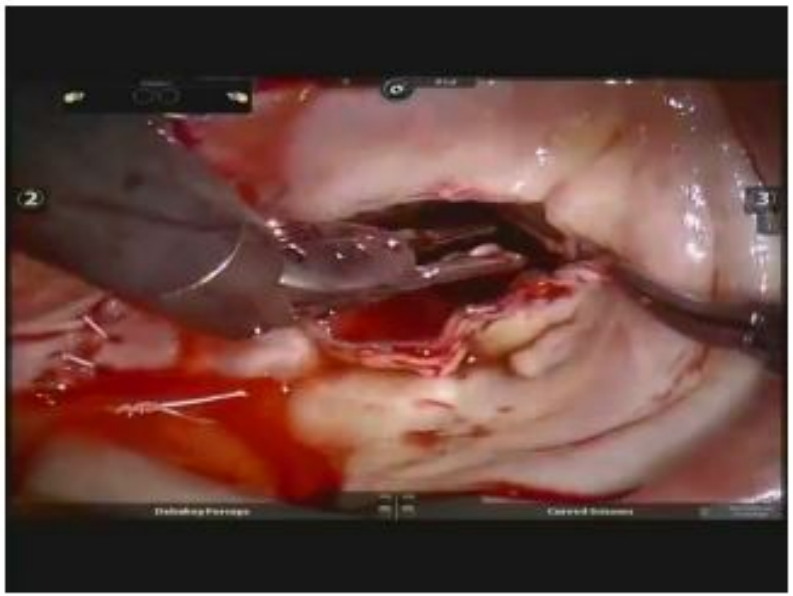
## Exploration applications

- Exploration operations: For these applications, working conditions are not suitable for humans. Such applications include work under water, in outer space, in nuclear power stations, and in high temperature environments.

# Classifications of robots

## Medical applications

- Medical applications:This application includes medical surgery as well as prostheses, and ortheses necessary for handicapped persons. Prostheses are the artificial hands and legs while ortheses are rigid motorized structures placed around appraised limbs to train their movements.



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## Social life applications

- Social life applications:Robots are used to enable humans to avoid undesirable jobs. An interesting example is the use of robots in sheep shearing in Australia.

# Classifications of robots

**Social life applications**(Service robots)

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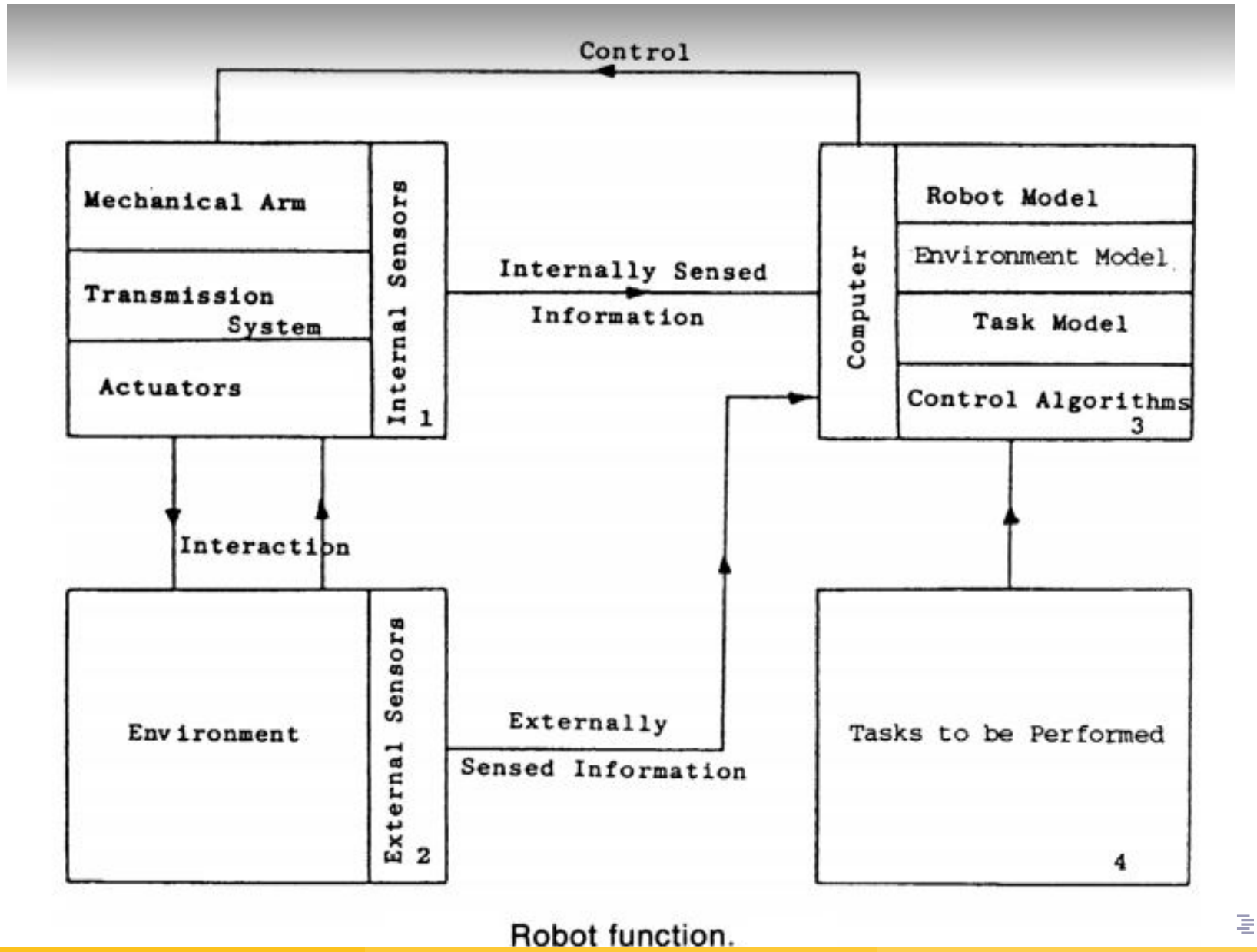
**Social life applications**(Service robots) with the integration of AI are used in our daily life like Robot vacuums, Robotic kitchen, Robotic nurses, Pet robots, Robotic consultants Robot tour guides, Robot managers, Delivery robots and Diagnostic robots.

# Break

## Questions

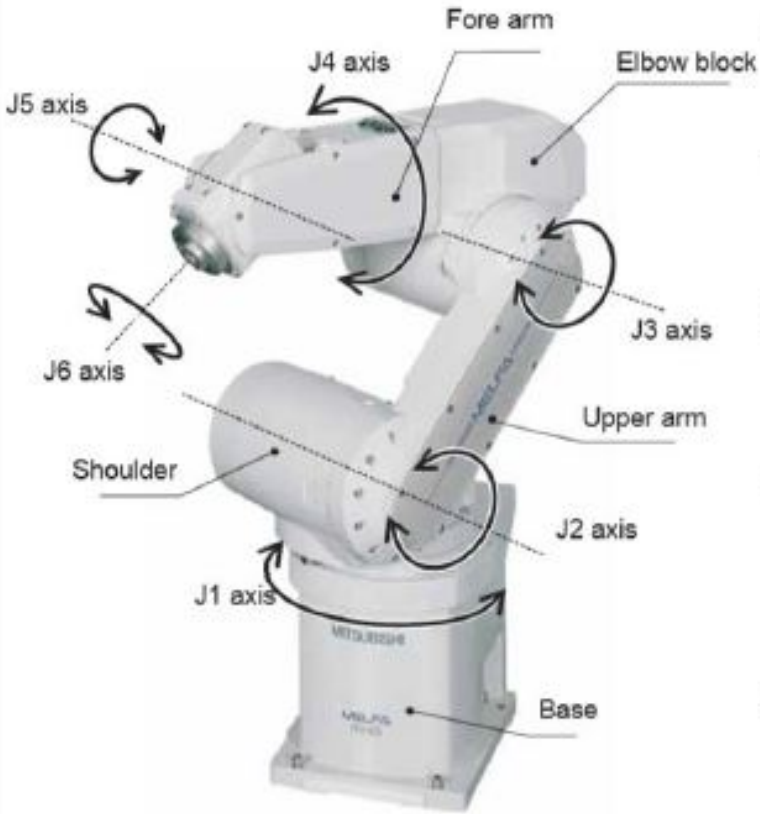
# Mathematical modeling of Robots




Robot function.

## Robots terminology

### Kinematics – Terminology




**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, welding gun...).

**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).

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- **Reach:** Indicates the maximum reach in the horizontal H, vertical V, and Lateral L directions.

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  - **Accuracy:** The capability of the computer controlled robot to position its end effector at a given target point within its working space.
  - **Repeatability** represents the ability of the manipulator to return repeatedly to the same location (previously target point).

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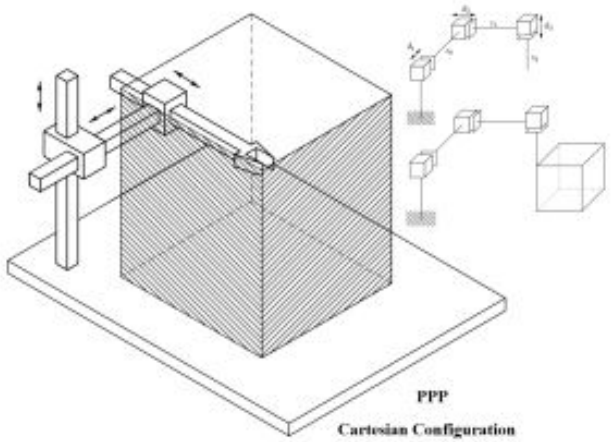
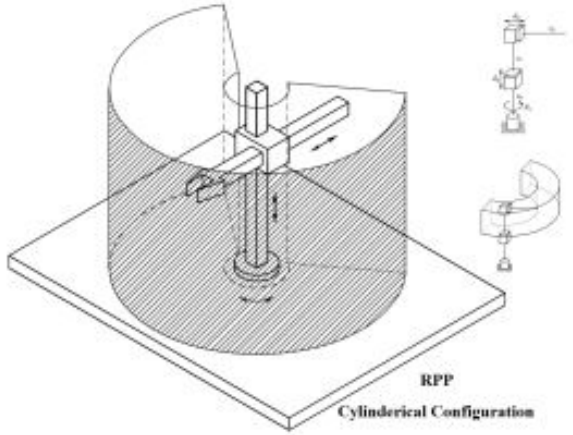
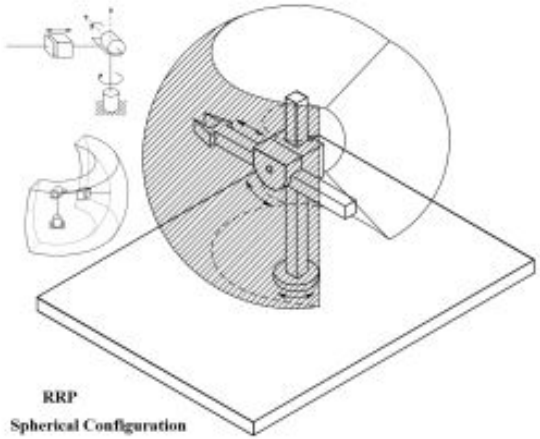
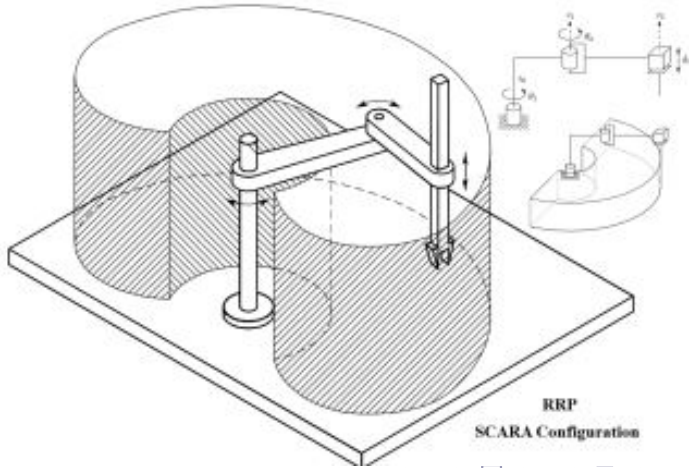
Manipulators consist of nearly rigid links, which are connected by joints that allow relative motion of neighboring links within specific area.



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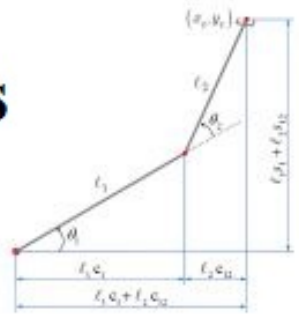
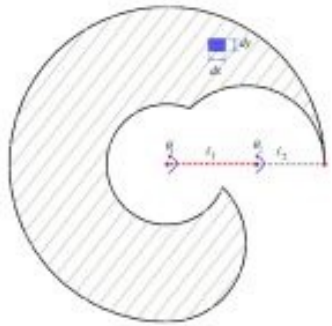
**Forward Kinematics**





**Degree of freedom**

**Modeling and Simulation**

**Numerically Simulation**

$$
\begin{aligned}
x_c &= \ell_1 \cos(\theta_1) + \ell_2 \cos(\theta_1 + \theta_2) \\
y_c &= \ell_1 \sin(\theta_1) + \ell_2 \sin(\theta_1 + \theta_2)
\end{aligned}
$$

**Equations of motion**

**Inverse Kinematics**

$$
\begin{aligned}
x &= \ell_1 c_1 + \ell_2 c_{12} \\
y &= \ell_1 s_1 + \ell_2 s_{12}
\end{aligned}
$$

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    - Traditional system dynamics.

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**The main types of mathematical modeling technics**

- In order to study the dynamics of a system it is necessary to understand the formulation system equations of motion and its components. The mathematical modeling procedures, starting from initial idea till reach the theoretical optimum design.
- Several general-purpose computer programs exist, which allow engineers to model complex mechanical systems and to evaluate the dynamic characteristics of potential designs before building of prototypes . This reduces cost and lead time in designs.
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  - Finite element analysis.

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  - Multibody system dynamics.

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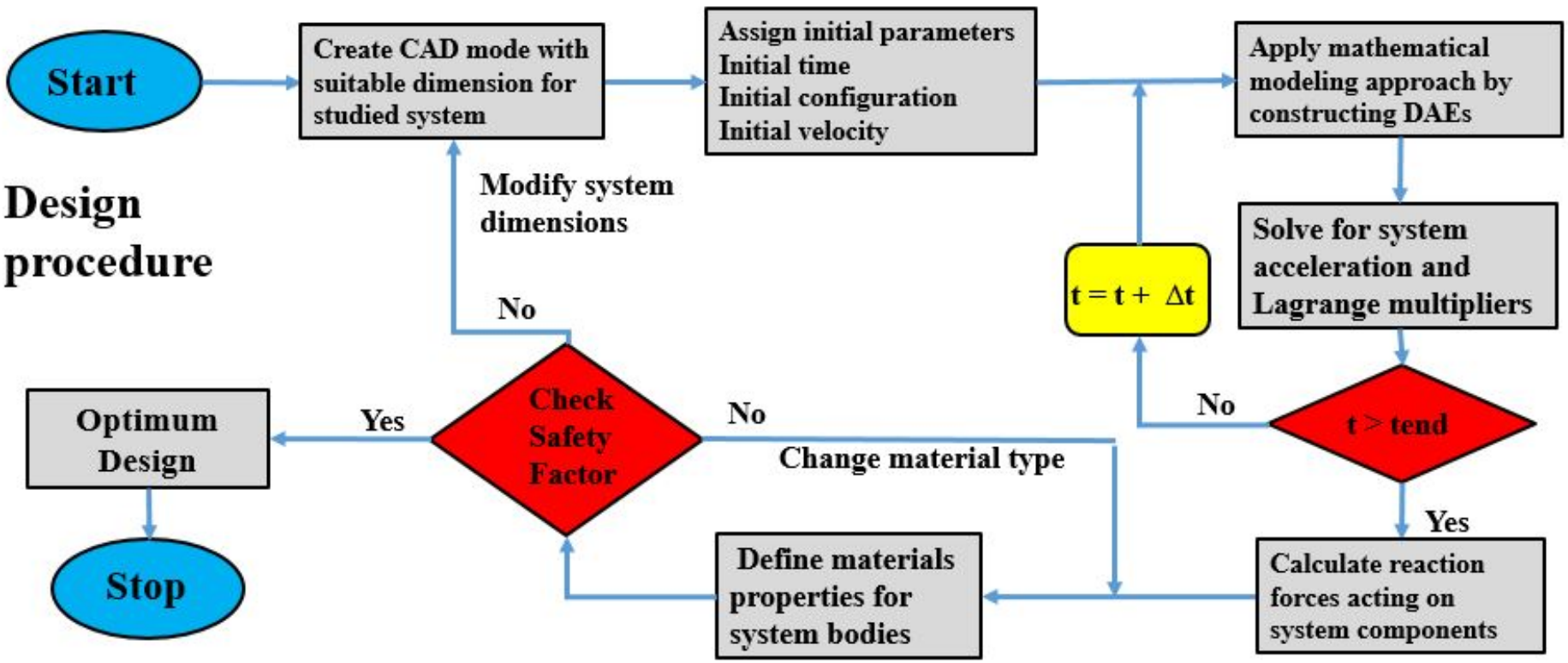
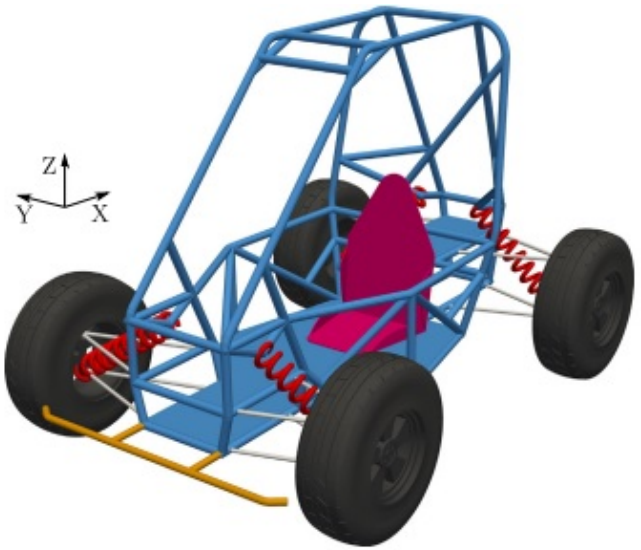


# Modern mathematical modeling applications

**Published Papers for modeling complex mechanical system**

Wallin, Michael, et al. "Evaluation of the accuracy of the rigid body approach in the prediction of the dynamic stresses of complex multibody systems." International journal of vehicle performance (2016).


Ebrahimi, Mehran, et al. "Design optimization of dynamic flexible multibody systems using the discrete adjoint variable method." Computers and Structures (2019).



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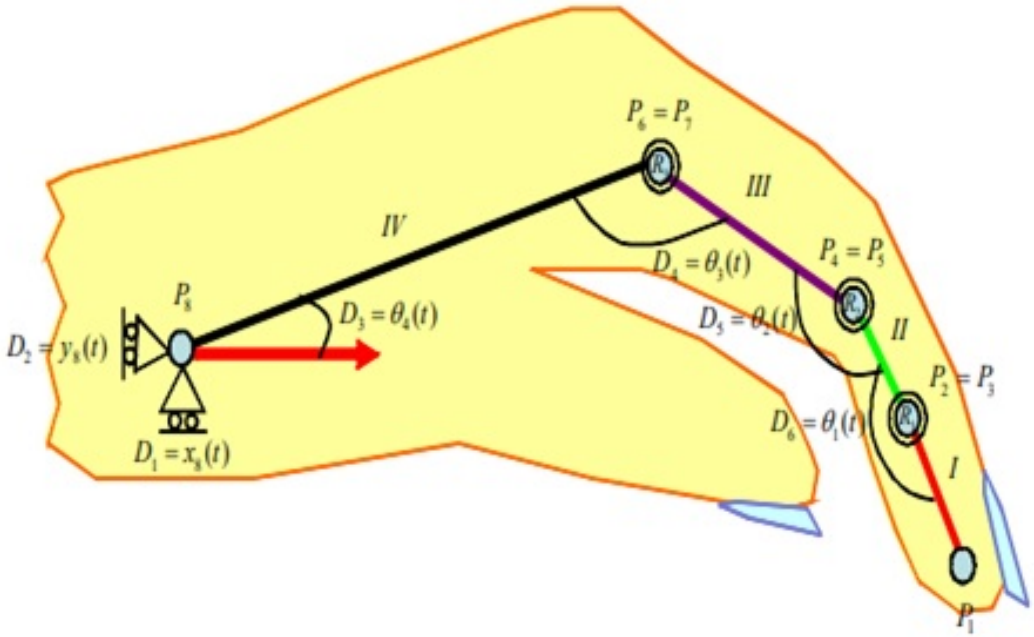
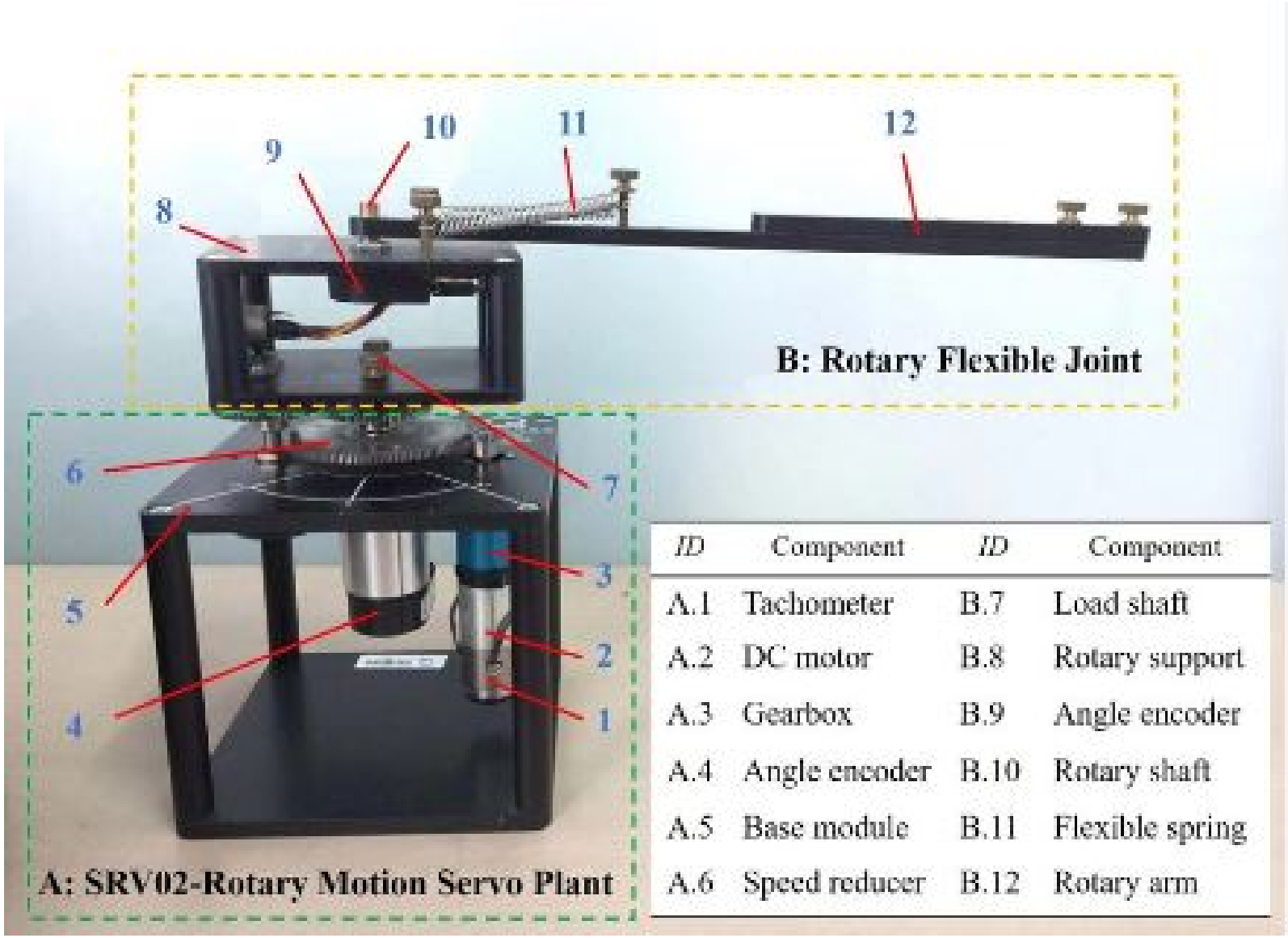
Sergio Savino, et al. "A mechanical hand for prosthetic applications: multibody model and contact simulation." Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine (2018).




Zanoni Alart, et al. "Multibody dynamics analysis of the human upper body for rotor craft–pilot interaction." Nonlinear Dynamics 102, 1517–1539 (2020).

## Invert pendulum test rig




| ID | Component | ID | Component |
|---|---|---|---|
| A.1 | Tachometer | B.7 | Load shaft |
| A.2 | DC motor | B.8 | Rotary support |
| A.3 | Gearbox | B.9 | Angle encoder |
| A.4 | Angle encoder | B.10 | Rotary shaft |
| A.5 | Base module | B.11 | Flexible spring |
| A.6 | Speed reducer | B.12 | Rotary arm |

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**(No cut and paste from web)**

# Lecture end

Thank You for Attention !!

Any Questions