Actuation and transmission design

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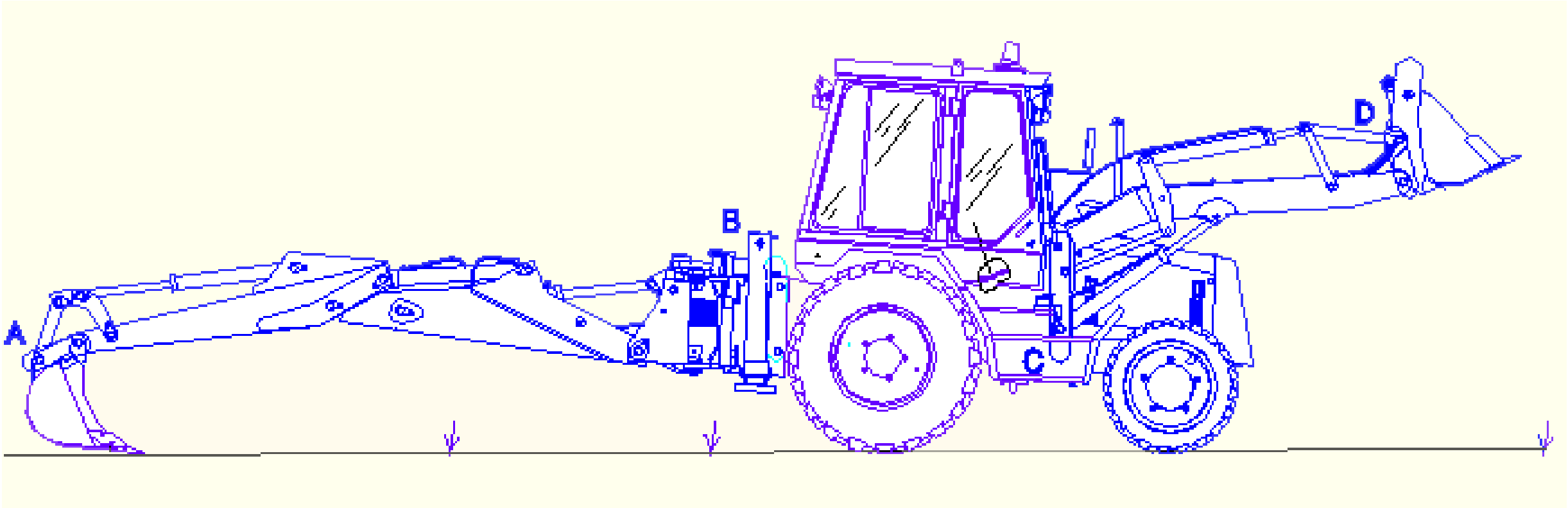
Mechanisms

Machine and mechanism

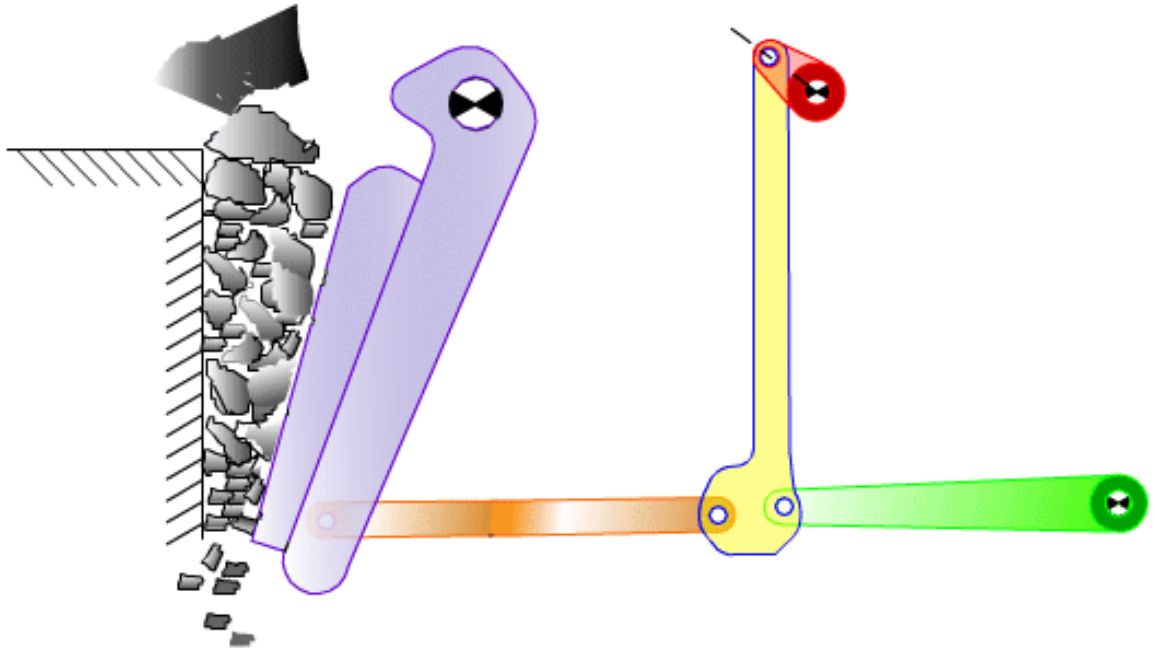
- A **machine** structure is constructed to perform a particular task.

- A **mechanism** is a group of rigid bodies through the study of which we can understand the basic structure of any machine and can design machines that are not in existence.

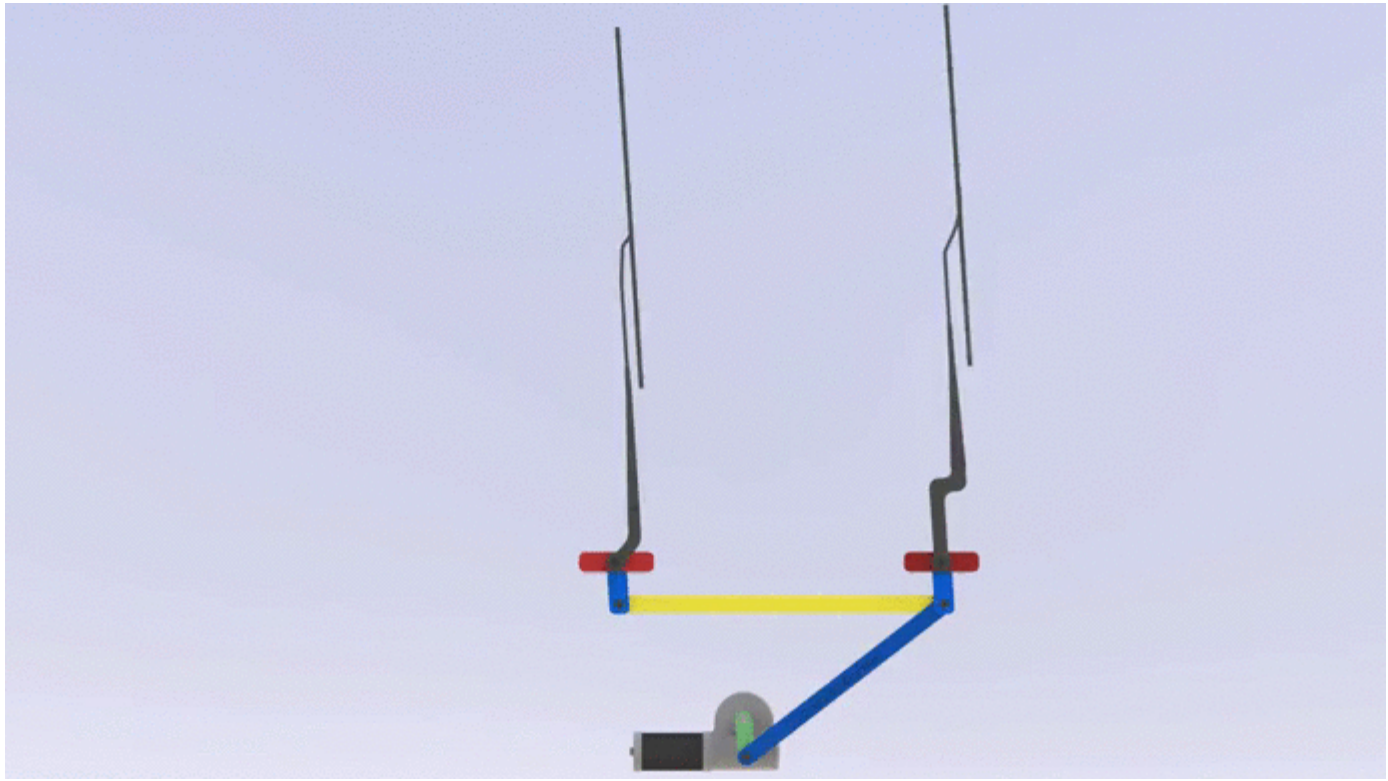
Backhoe - Excavator

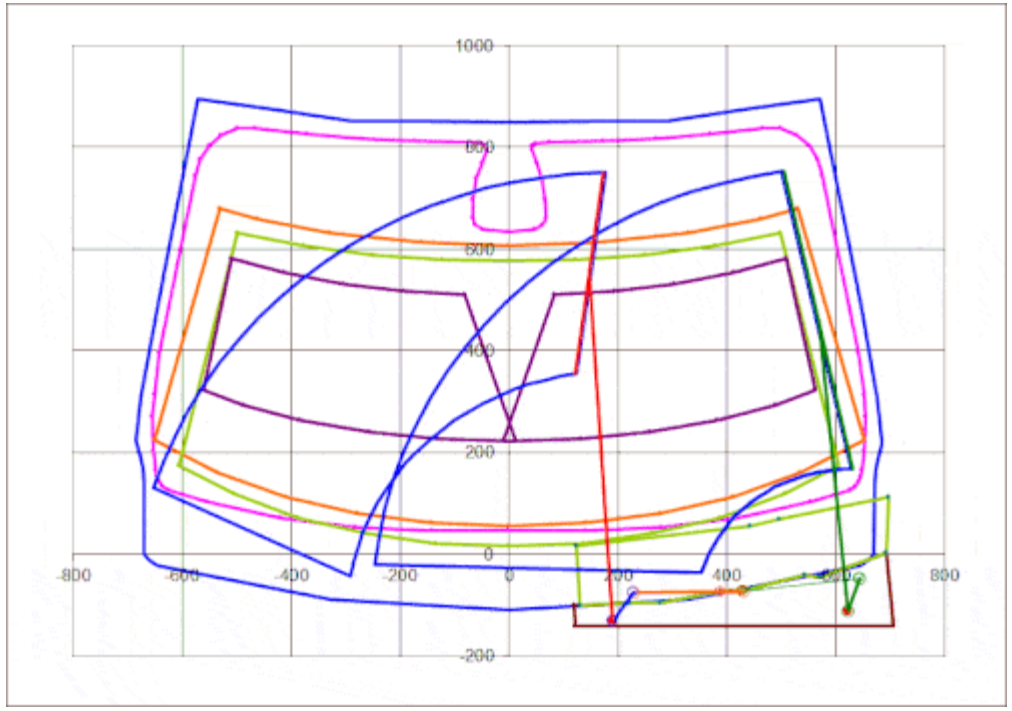


Rock breaker



Windshield wiper

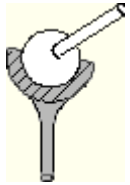




Mechanism definitions

- **Kinematic element,** is that part of a rigid body which is used to connect it to another rigid body such that the relative motion between the two rigid bodies can occur.

- **Kinematic pair** or **joint**, is the joining of two kinematic elements.
  - **Closed kinematic pairs**.



  - **Open kinematic pair**.

More definitions

- If a rigid body contains at least two kinematic elements we shall call it a **link**. A link may have more than two kinematic elements (but not less than two).

- The links connected to each other by kinematic pairs will form a **kinematic chain**. If all the kinematic pairs are closed, than we have a closed kinematic chain. If one of the kinematic pair is of open type, the kinematic chain is an open kinematic chain.

- If one of the links in a kinematic chain is fixed, then the system thus obtained is called a **mechanism**.

Degree of freedom

- The degree-freedom of space is the **number of independent parameters to define the position of a rigid body in that space**.

Degree of freedom – spatial

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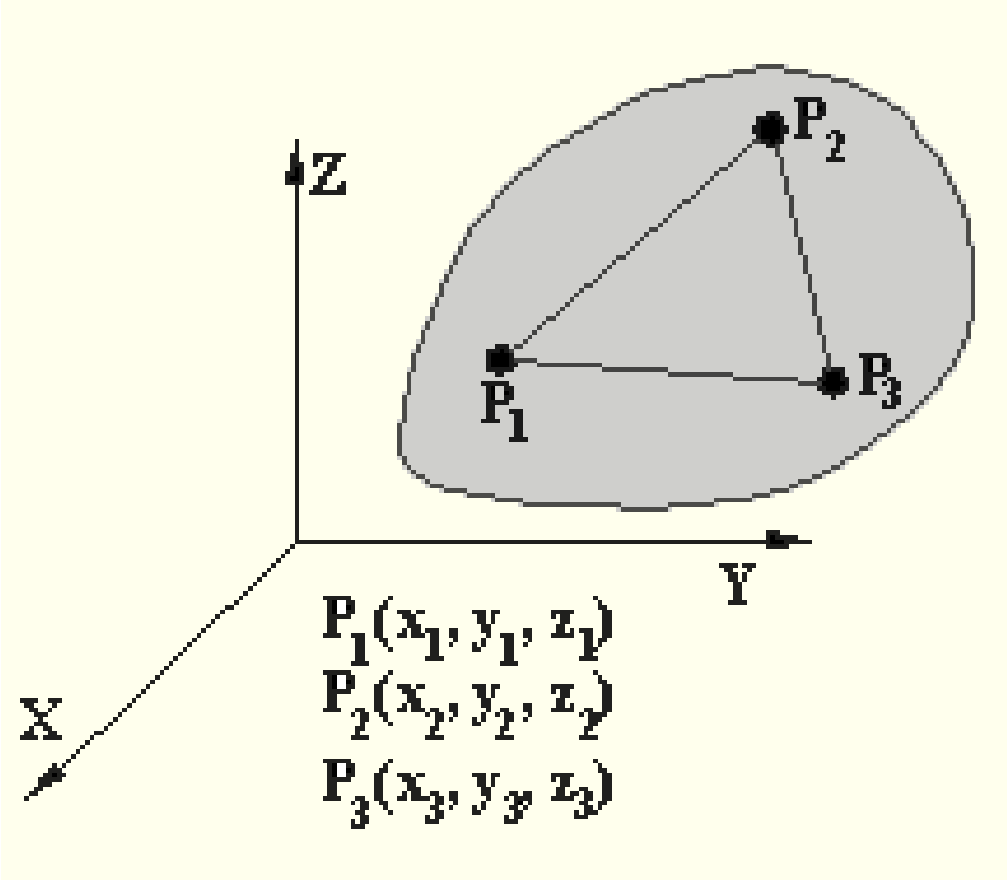
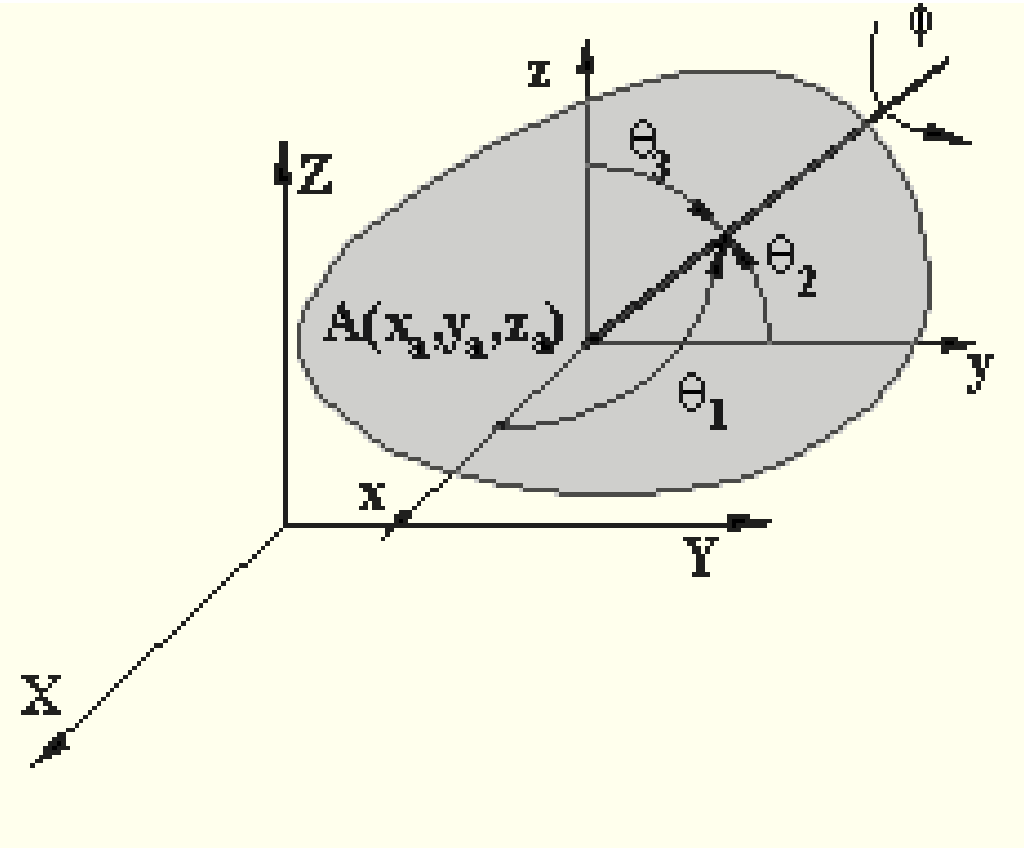


$$(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2 = a_1^2$$

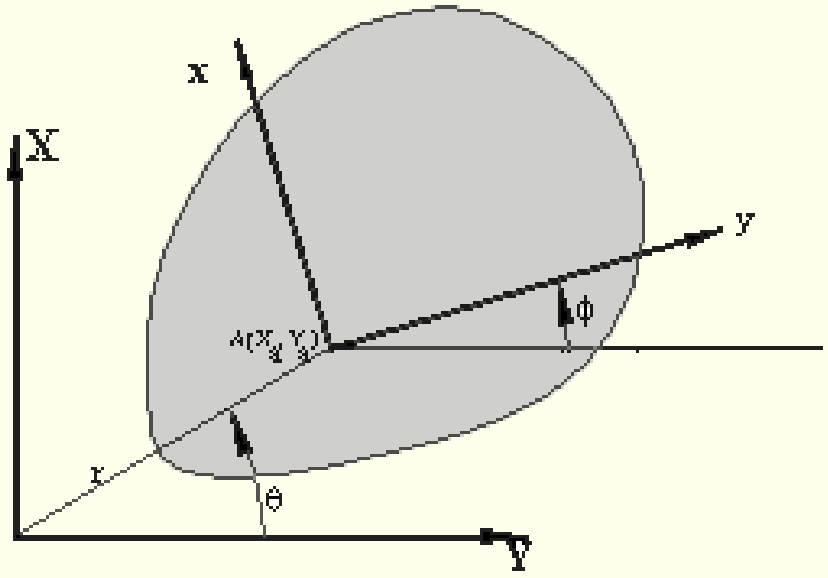
$$(x_3 - x_1)^2 + (y_3 - y_1)^2 + (z_3 - z_1)^2 = a_2^2$$

$$(x_3 - x_2)^2 + (y_3 - y_2)^2 + (z_3 - z_2)^2 = a_3^2$$

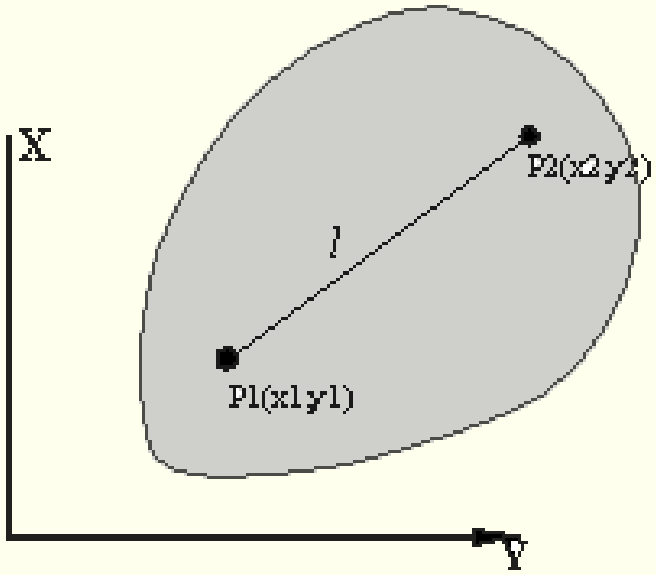
Degree of freedom – spatial



Degree of freedom – planar



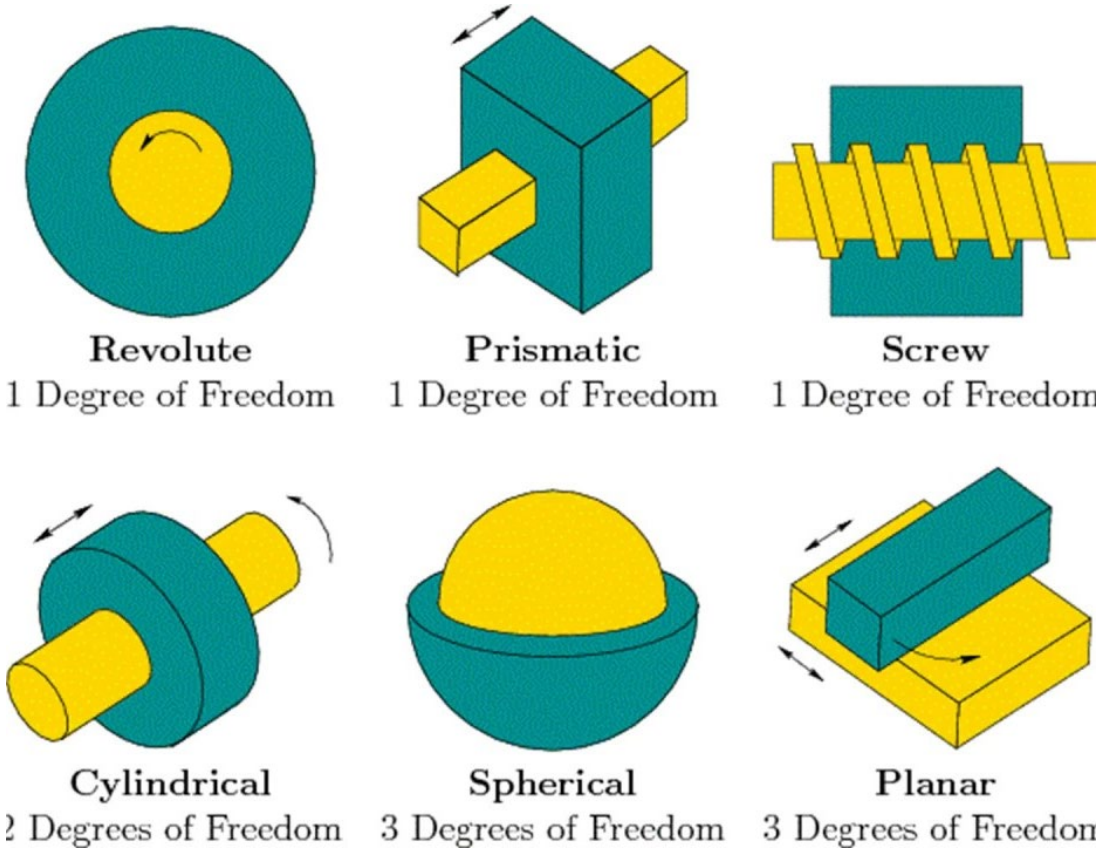
Polar or rectangular representation



Geometric representation

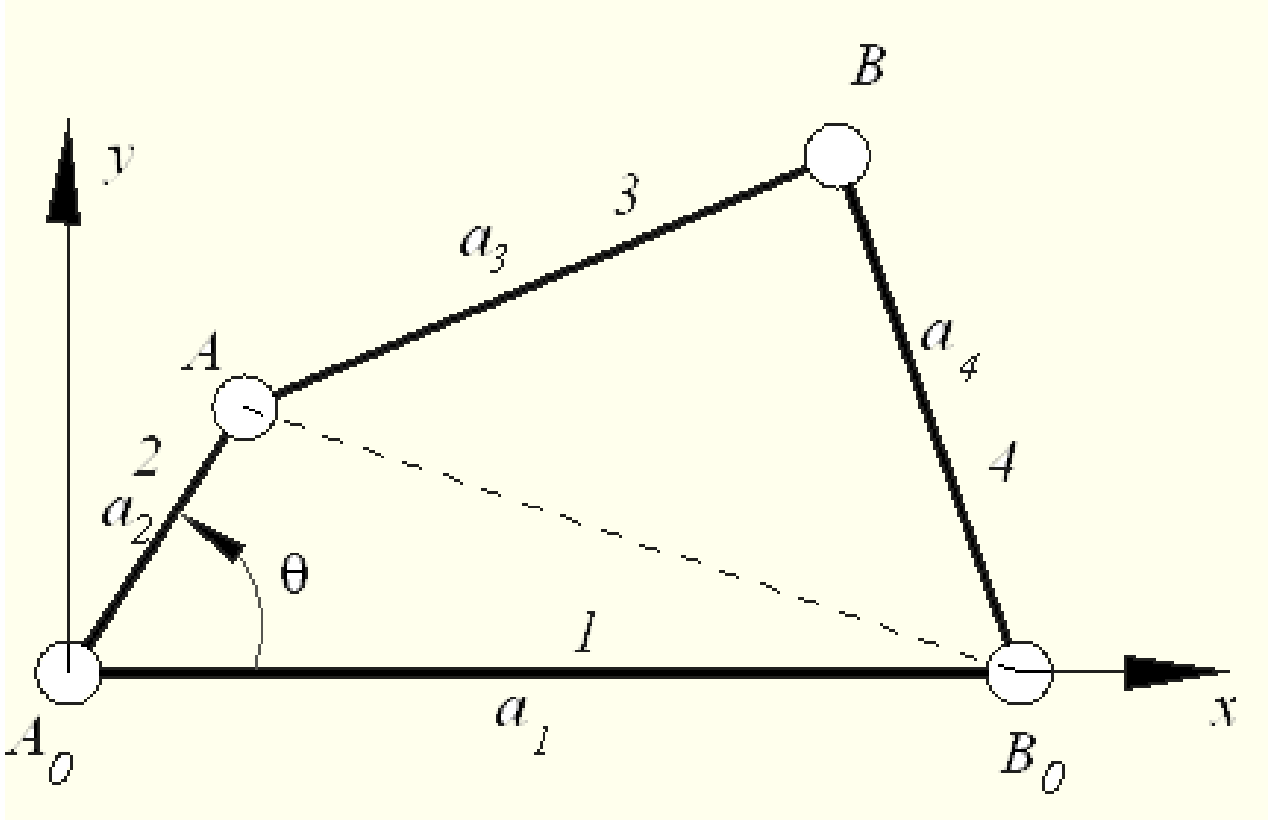
Degree of freedom – mechanism

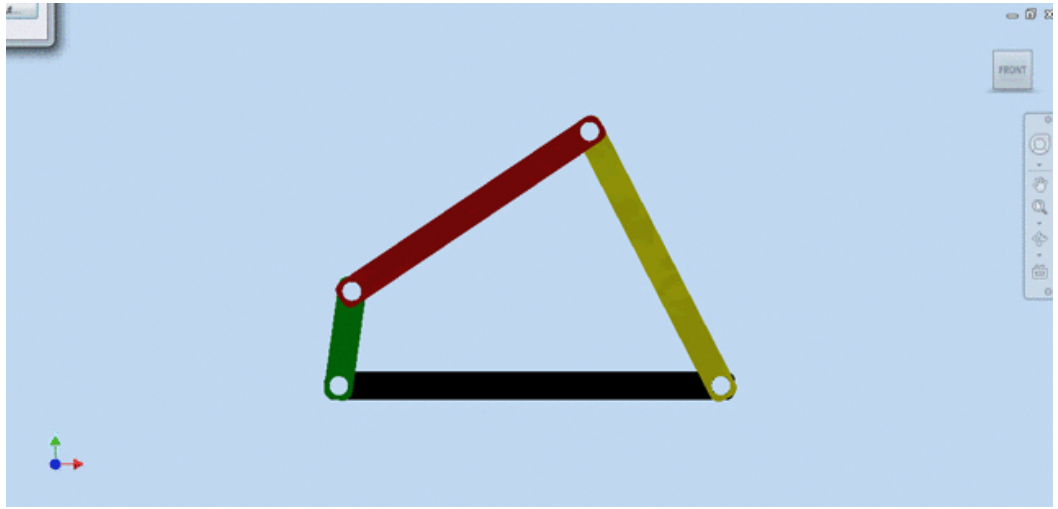
- **The degree-of-freedom** of a kinematic pair is defined as the **number of independent parameters that is required to determine** the **relative position of one rigid body with respect to the other connected by the kinematic pair**.



Degree of freedom – mechanism

- The degree of freedom of a mechanism is the number of independent parameters required to define the position of every link in that mechanism





Degree of freedom – mechanism

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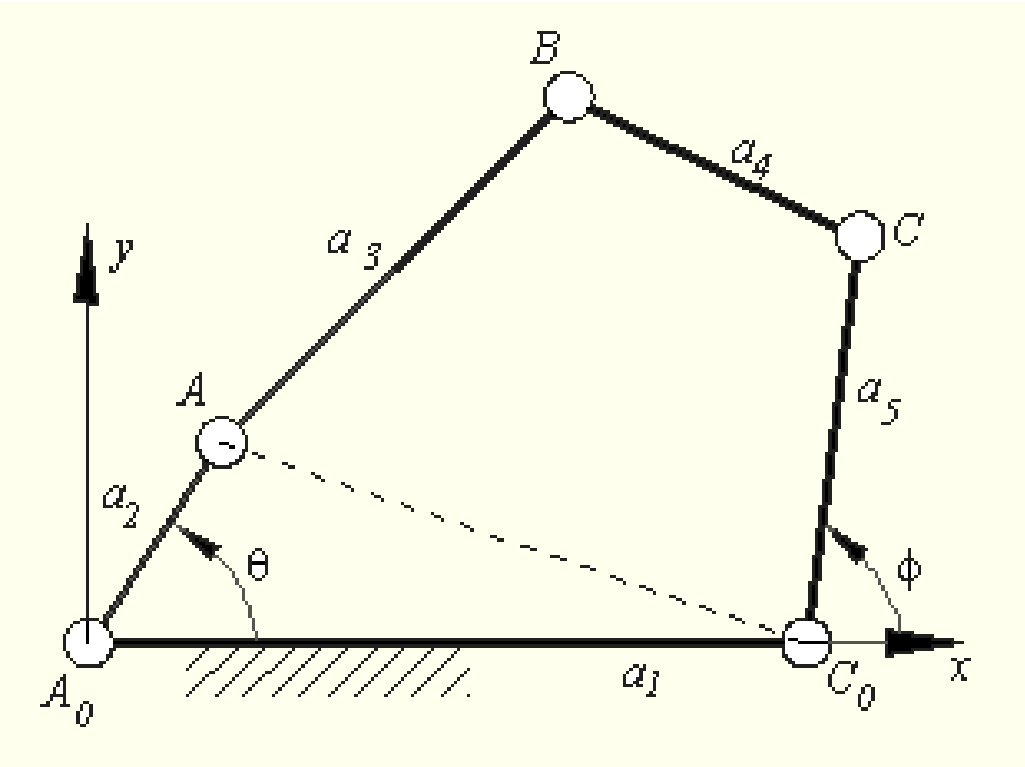
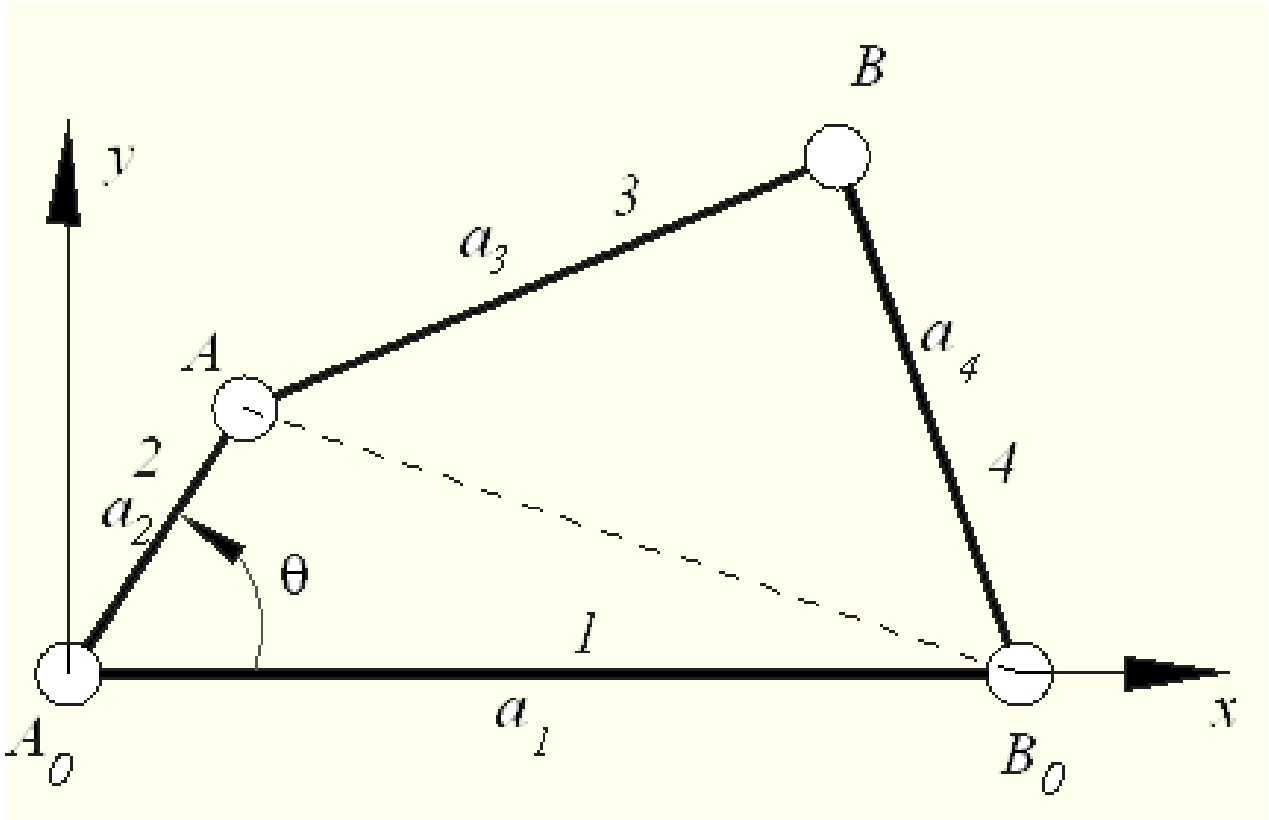


Degree of freedom – mechanism

- λ: Degree of freedom of space ($\lambda = 3$ for planar space ; $\lambda = 6$ for spatial space)
- l : The number of links in a mechanism (including the fixed link)
- j : The number of joints in a mechanism
- f_i : The degree of freedom of the ith joint in the mechanism
- F : The degree of freedom of the mechanism
- $F = \lambda(l - j - 1) + \sum_{i=1}^{j} f_i$ **General Degree-of-Freedom Equation**

Degree of freedom – mechanism

- The degree of freedom of a mechanism is the number of independent parameters required to define the position of every link in that mechanism



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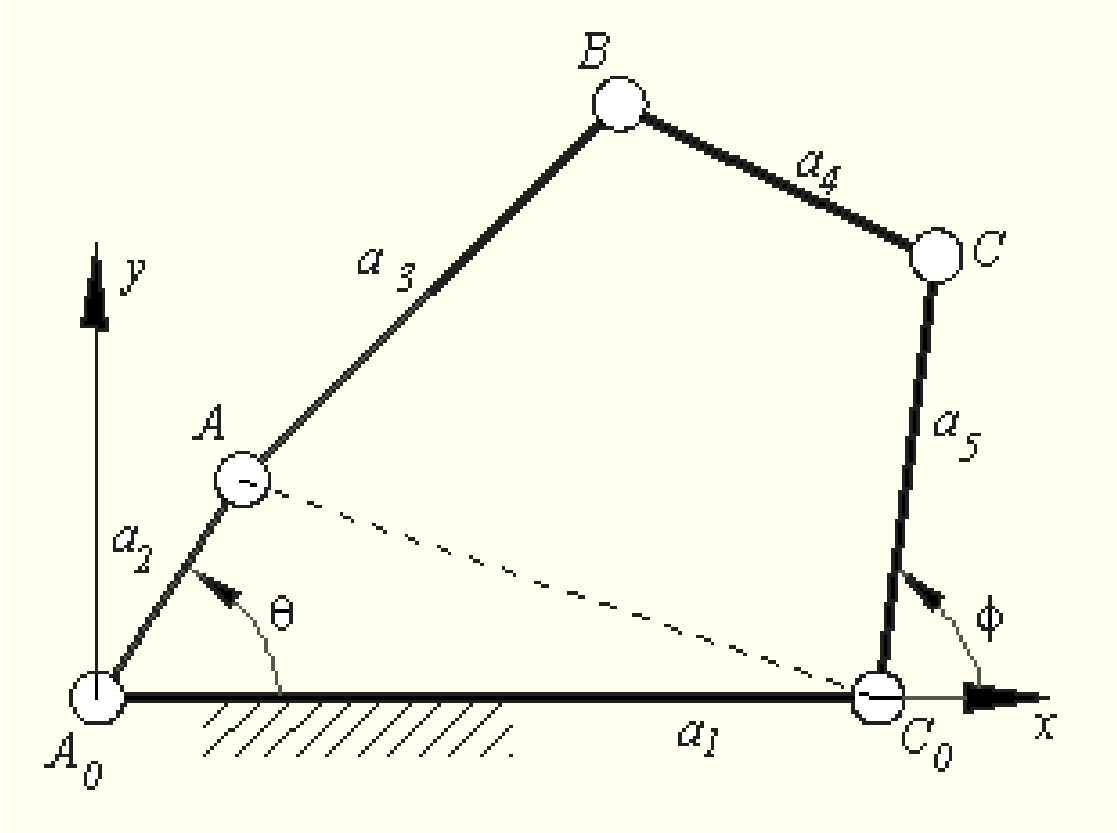
- λ: 3
- l : 4
- j : 4
- f_i : 1
- $F = 1$

Degree of freedom – mechanism

- The degree of freedom of a mechanism is the number of independent parameters required to define the position of every link in that mechanism



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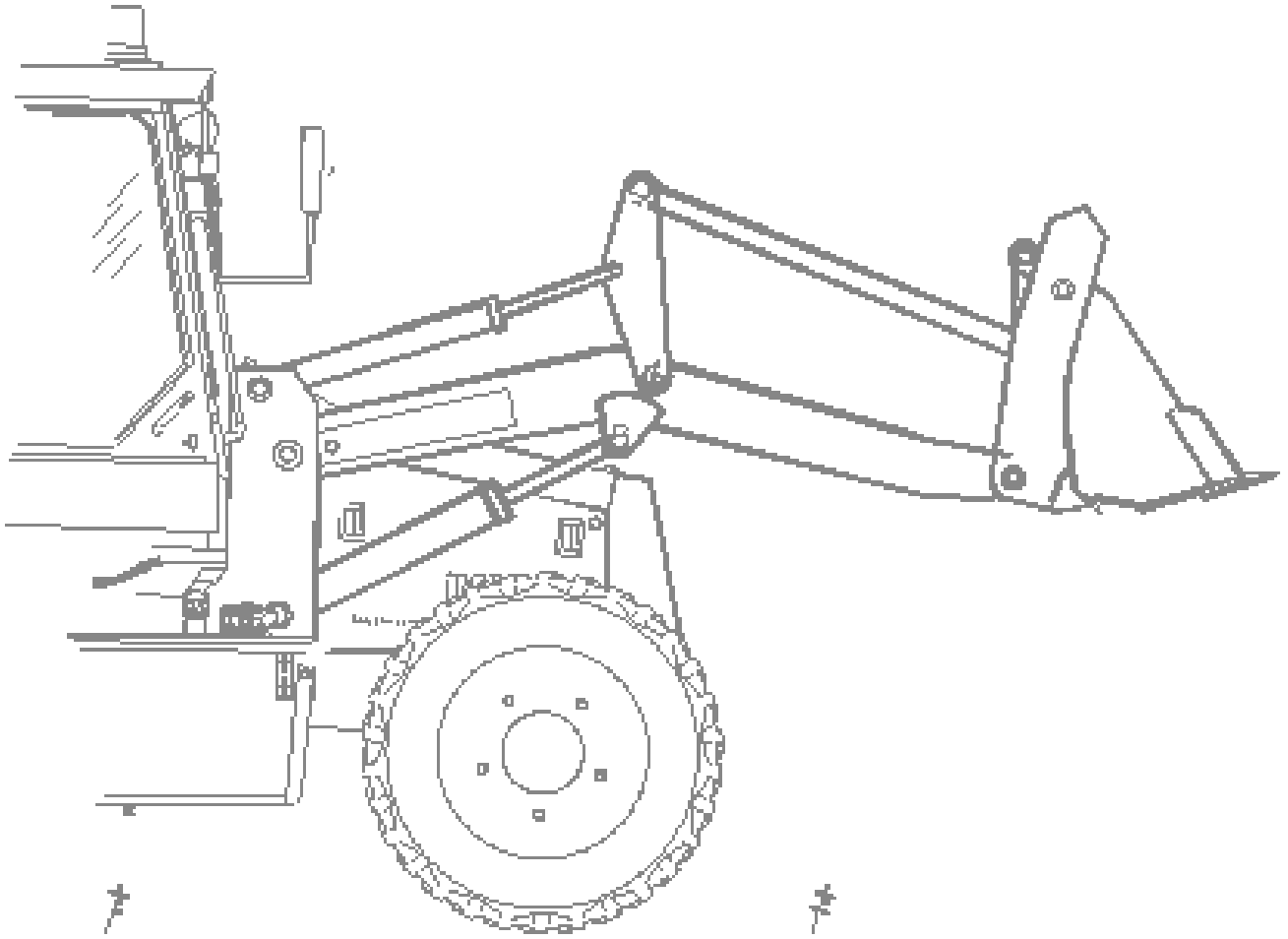
- F : The degree of freedom of the mechanism
- $F = \lambda(l - j - 1) + \sum_{i=1}^{j} f_i$

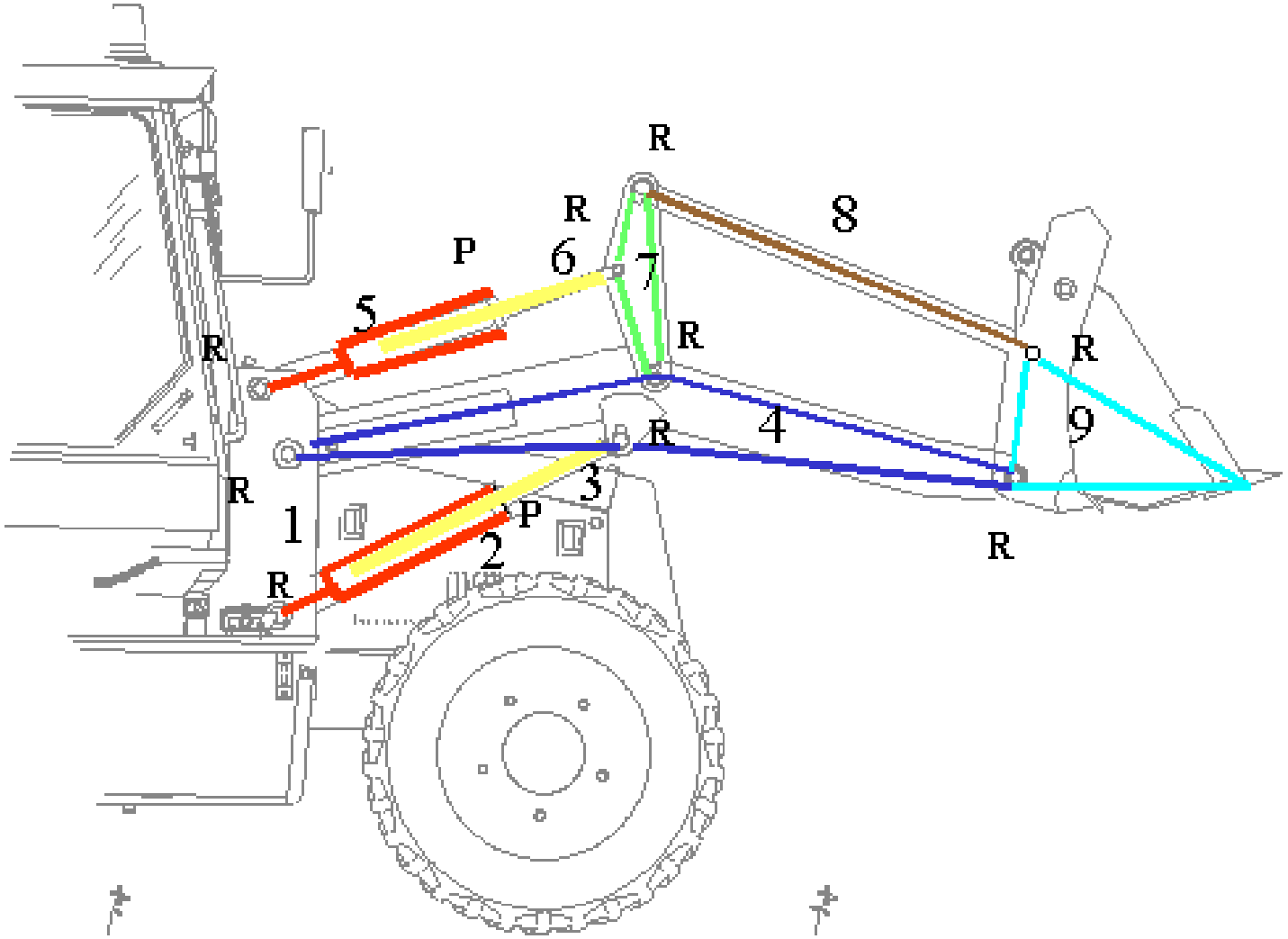
- λ: 3
- l : 5
- j : 5
- f_i : 1
- $F = 2$

Degree of freedom – mechanism



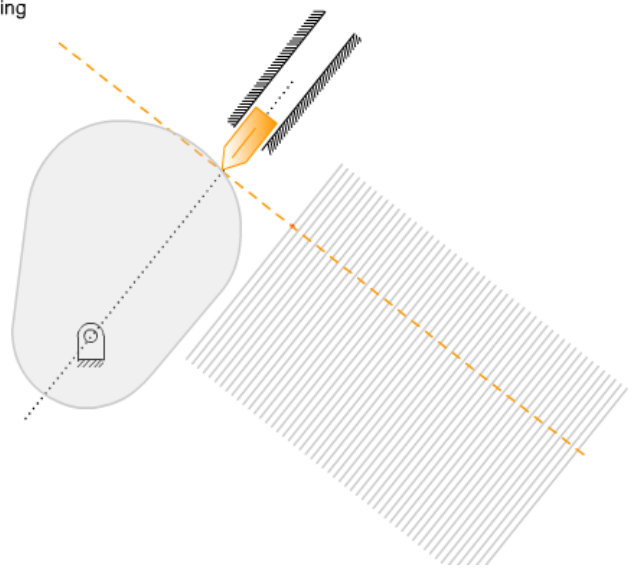
Degree of freedom – mechanism

- $l = 9$
- $j = 11\ (9\ revolute, 2\ prismatic)$
- $fi = 1\ (for\ all\ joints)$
- $\lambda = 3\ (planar\ motion)$
- $F = 3\ (9 - 11 - 1) + 11$
- $F = -9 + 11$
- $F = 2$

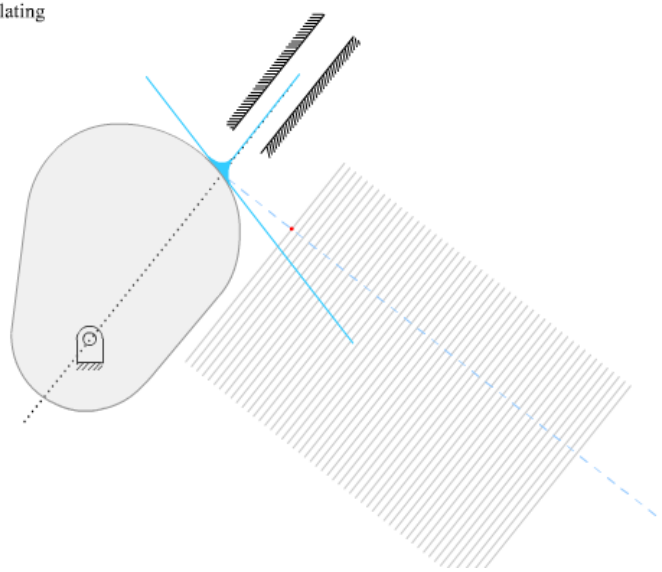


More mechanisms – cam

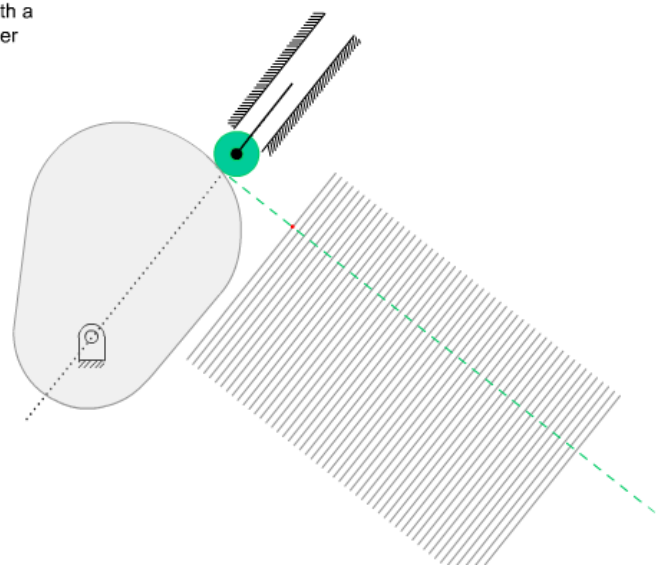
In-line translating knife edged follower



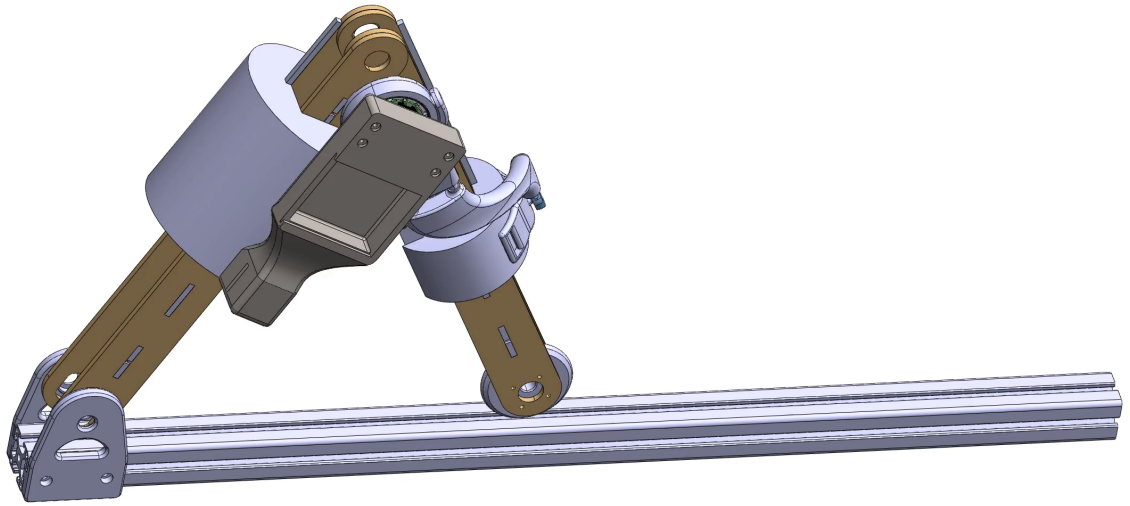
Flat faced translating follower



Radial cam with a translating roller follower



More mechanisms – slider-crank



Reference

https://blog.metu.edu.tr/eresmech/mechanisms/

Next week

- **Shape Memory Alloy Actuators Demo: loading & bidirectional movement**
- **You will be divided into groups of 3.**
- **2 computers for each group with internet connection are necessary!**