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Mechanisms

Theory and Examples

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Motto:

“I have been impressed with the urgency of doing. Knowing is not enough; we must apply. Being willing is not enough; we must do.”

(Leonardo da Vinci)

Preface

The work "*Mechanism. Theory and examples*" is a guide addressed to students of the Faculty of Mechanical Engineering for the Mechanisms discipline, covering aspects related to the design, analysis and synthesis of articulated bar mechanisms, gear mechanisms, and cam mechanisms. The guide is structured into 9 chapters and an appendix, each paper including a theoretical part, practical examples, and exercises to solve.

Due to the fact that the purpose of the book is educational, graphic and analytical methods of analyzing the structure and behavior of some representative mechanisms have been included and presented in detail. The presentation of solved examples that complement the theory elements at the beginning of each paper helps to fix and consolidate the concepts, as well as to better understand how the presented mechanisms work.

In addition to the analytical methods presented, the guide also presents how to implement them using simulation and computer-aided design software tools (MATLAB® and SOLIDWORKS®). The student thus receives the necessary information to understand and deepen the role of the mechanisms and principles underlying their operation, thus having the bases to be able to develop the year project for the Mechanisms discipline.

The authors express their gratitude to all those who supported them during the writing of the paper, especially to Prof. Dr. Eng. Petre Alexandru. At the same time, the authors would also like to pay tribute in this way to the one who was an outstanding specialist and mentor, Prof. Dr. Eng. Doru Talabă.

Contents

Laboratory 1. The structure of mechanisms, fundamentals and examples

Laboratory topic

For the given mechanisms, do the following:

- Skeleton representation;
- Identify the links and pairs (kinematic elements and joint);
- Compute the degree of freedom.

Objectives

Following the laboratory work, the student will be able to:

- recognizes different types of kinematic links and pairs;
- realize the skeleton representation of a mechanism;
- calculate the degree of freedom of mechanisms.

Fundamental knowledge

Mechanism - a technical system for transmitting and transforming movements and forces. It comprises kinematic elements (links) connected by mobile connections (pairs or kinematic joints).

Skeleton representation - the structural model of the mechanism in which links and pairs are represented in simplified form.

Kinematic element (link) - a part or a group of parts rigidly connected together (no relative movement), forming a kinematic unit. It is mobile during the operation of the mechanism. Examples: crank, connecting rod, rocker, gear, cam (Figure 1.1. – Figure 1.4).

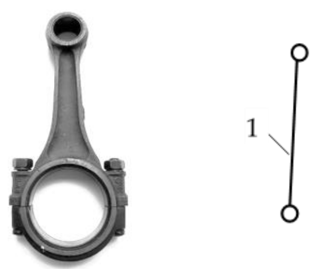


Figure 1.1. Connecting rod

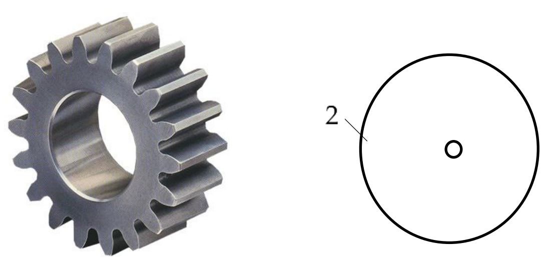


Figure 1.2. Gear

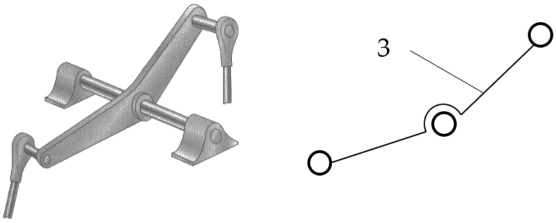


Figure 1.3. Rocker

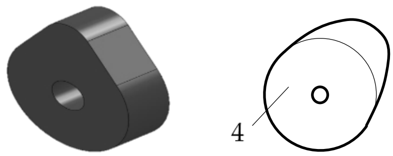
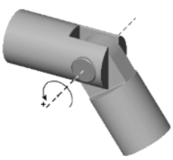
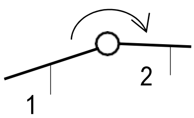
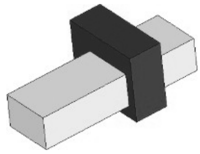
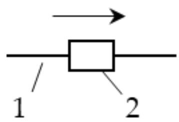
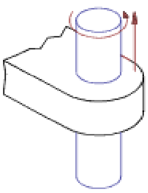
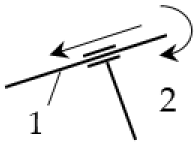
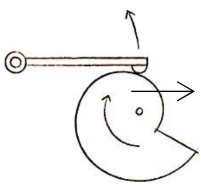
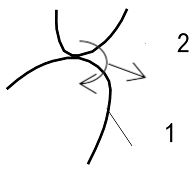


Figure 1.4. Cam

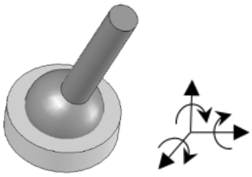
Kinematic joint - the direct and mobile connection between two kinematic elements (links), the relative movement defined by the contact area between the two elements. Ex. pin in a slot, guides, profiles.

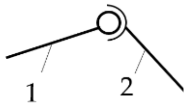
Degree of freedom of a pair (DOF) - f – the number of relatively independent movements allowed to the two coupled links. The free (unbound) element has 6 movements (three linear displacement and three rotations), and the joints are cancelling some of them: one link compared to the other one can move in certain directions (linear displacement) or rotate around certain axes (rotation), but is not allowed to move or rotate in other directions. Thus, the degree of freedom can be **f = 5,4,3,2,1** (also, it is the number of independent parameters required to determine the position of one relative to the other). Restrictions introduced by the joints: **r = 6-f**.

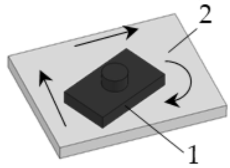
Table 1.1. Type of pairs

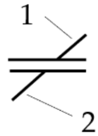
f = 1 – one DOF, allows a relative rotation or translation			
Revolute (pin) joint - R		Translational (slider, prismatic) joint - T	
			
f=2 – two DOF, allows two relative movements			
Cylindrical joint - C		Two profiles in plane - Rt (roto-translation)	
			
f=3 – three DOF, allows three relative movements			

Spherical joint - S	Planar joint



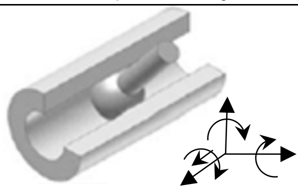


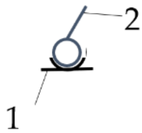


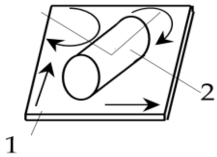


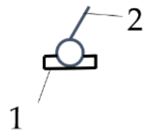
f=4 – four DOF, allows four relative movements

Sphere in cylindrical slot	Cylinder - plain



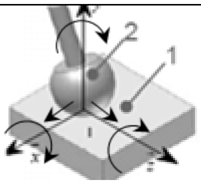


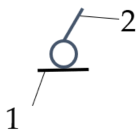


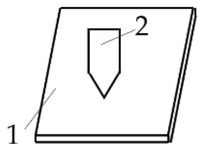


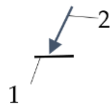
f=5 – five DOF, allows five relative movements

Point contact









Kinematic chain – a sequence of links (kinematic elements) connected by pairs (kinematic joints):

- open kinematic chain,
- closed kinematic chain (forming a closed loop).

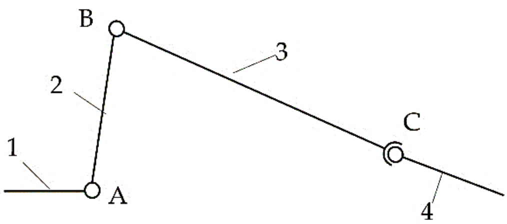


Figure 1.5. Open kinematic chain

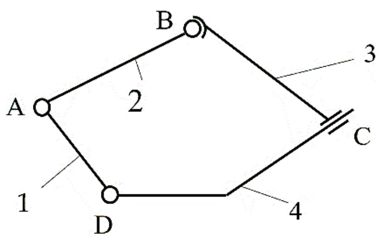


Figure 1.6. Closed kinematic chain

Mechanism - closed kinematic chain having a fixed element (base) and determined motion.

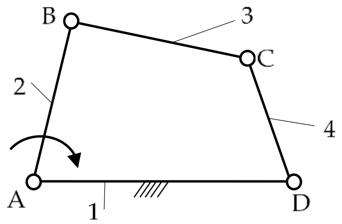
Mechanisms can be planar or spatial.

Mechanisms can have a single loop or multiple loops.

Examples: four-bar mechanism, crank-slider mechanism, Hook mechanism, spatial four-bar mechanism, gear mechanism, cam mechanism.

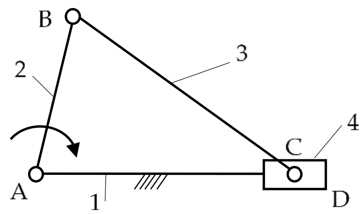
Table 1.2. Examples of planar and spatial mechanisms

Four-bar mechanism



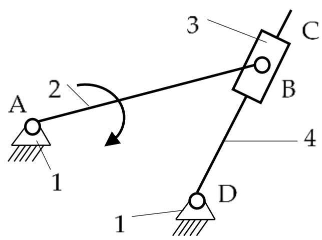
A: $R_{1\text{-}2}$, f=1
B: $R_{2\text{-}3}$, f=1
C: $R_{3\text{-}4}$, f=1
D: $R_{4\text{-}1}$, f=1
$c_1 = 4$
n = 4
M = 3(4-1) - 2*4 = 1
M = Σf_i – S = 4 – 3 = 1

Crank-slider mechanism



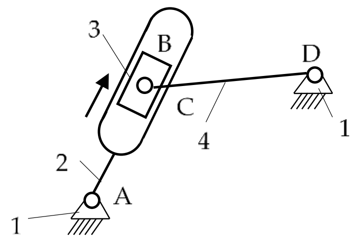
A: $R_{1\text{-}2}$, f=1
B: $R_{2\text{-}3}$, f=1
C: $R_{3\text{-}4}$, f=1
D: $T_{4\text{-}1}$, f=1
$c_1 = 4$
n = 4
M = 3(4-1) - 2*4 = 1
M = Σf_i – S = 4 – 3 = 1

Mechanism with a slider



A: $R_{1\text{-}2}$, f=1
B: $R_{2\text{-}3}$, f=1
C: $T_{3\text{-}4}$, f=1
D: $R_{4\text{-}1}$, f=1
$c_1 = 4$
n = 4
M = 3(4-1) - 2*4 = 1
M = Σf_i – S = 4 – 3 = 1

Oscillating mechanism



A: $R_{1\text{-}2}$, f=1
B: $T_{2\text{-}3}$, f=1
C: $R_{3\text{-}4}$, f=1
D: $R_{4\text{-}1}$, f=1
$c_1 = 4$
n = 4
M= 3 (4-1) - 2*4 = 1
M = Σf_i – S = 4 – 3 = 1