MIET2510

Mechanical Design

Week 1 – Analysis of Mechanisms – Part 2

School of Science and Technology, RMIT Vietnam



Outlines

- 1. Number Synthesis
- 2. Paradoxes
- 3. Linkage Transformation
- 4. Other Examples on Mobility Calculation



1. Number Synthesis

The term **Number Synthesis** means the determination of the number and order of links and joints necessary to produce motion of a particular DOF. Link order in this context refers to the number of nodes per link (binary, ternary, quaternary, etc.).



1. Number Synthesis

- For simplicity, lets name various links as B (Binary), T (ternary), Q (Quaternary), and P (Pentagonal), etc.
- The total of links in any mechanism will be L = B + T + Q + P + H (1)
- To find number of joints: J = (2B + 3T + 4Q + 5P + 6H)/2 (2) as two link nodes make one joint.
- Combine with M = 3(L-1) 2J (3) we have: L 3 M = T + 2Q + 3P + 4H (4)
- Using (1) and (4) to find the possible combinations of links for a particular DoF.



2. Paradoxes

- Gruebler's equation: M = 3(L-1) 2 * J1 J2
- Applying this equation, we pay no attention to link size and shapes. It can

give misleading results in the face of unique geometric configurations.



M = 3(5-1) - 2 * 6 - 0 = 0 DOF→ Movement is not possible



Same architecture, but the length of the links are equal, leading to 1-DOF.



3. Linkage Transformation

There are several transformation techniques or rules that we can apply to planar kinematic chains:

- 1. Revolute joints in any loop can be replaced by prismatic joints with no change in DOF of the mechanism, provided that at least two revolute joints remain in the loop.
- 2. Any full joint can be replaced by half joint, but it will increase DOF by 1.
- 3. Removal of a link will reduce DOF by one.



3. Linkage Transformation

- 4. The combination of rules 2 and 3 will keep unchanged DOF.
- Any ternary link can be shrunk to a lower-order link by coalescing nodes.
 This will create a multiple joints but will not change DOF.
- 6. Complete shrinkage of higher-order link is equivalent to its removal. A multiple joint will be created and DOF will be reduced.



3. Linkage Transformation

Example for Rule 1. Revolute joints in any loop can be replaced by prismatic joints with no change in DOF of the mechanism, provided that at least two revolute joints remain in the loop.



3. Linkage Transformation

Example for Rule 4. The combination of rules 2 and 3 will keep unchanged DOF.





4. Examples for Mobility Determination







4. Examples for Mobility Determination

a. Number of links L := 6Number of full joints $J_1 := 7$ Number of half joints $J_2 := 1$

$$M := 3 \cdot (L-1) - 2 \cdot J_1 - J_2$$
$$M = 0$$





4. Examples for Mobility Determination





Thank you for your attendance :D





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• Design of Machinery by Robert L. Norton.

