Kinematics & Dynamics of Machinery (ME 3320)

Recitation - 1

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1. **Agenda:**
   - Revision
   - Problems

2. **Revision:**

   - **What is the meaning of degrees of freedom(f_i)?**
     In how many ways the mechanism can move for a given configuration of its parts

   - **Complete the following tables:**

Configuration of Parts	Degrees of Freedom
Rigid(no motion)	**0**
Prismatic	**1**
Revolute	**1**
Parallel Cylindrical	**2**
Cylindrical	**2**
Spherical	**3**
Planar	**3**
Edge Slider	**5**
Cylindrical Slider	**5**
Point Slider	**6**
Spherical Slider	**6**
Crossed Cylinder	**6**

Joints	DOF(f_i)
Revolute(R)	**1**
Prismatic(P)	**1**
Cam	**2**
Spherical(S)	**3**
Cylindrical(C)	**2**

- **In Dr. Deemyad's notes, he mentions that a geometrical object in 3D has 6 degrees of freedom. The 3 points define the position of the origin of the object. What do the other 3 points represent?**
  Angles with respect to each of the axis in 3D

- **What is the expression to evaluate the Mobility of a planar mechanism(in 2D)?**

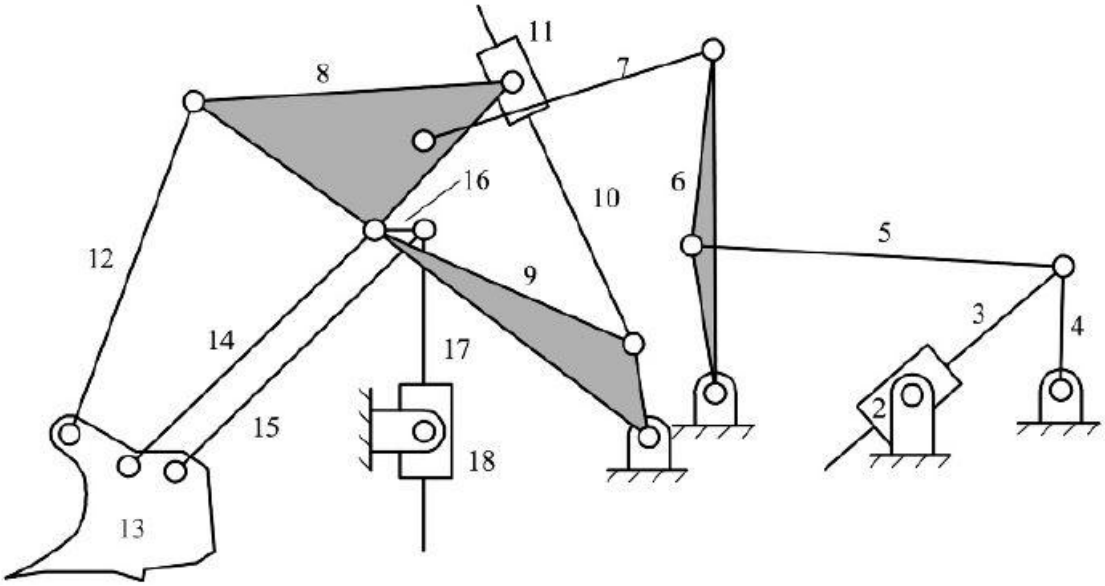
$$M = \underbrace{3(n-1)}_{\text{D.O.F of all Links}} - \underbrace{\sum_{i=1}^{j}(3-f_i)}_{\text{Constraints imposed by joints}}$$

  n = number of links in a mechanism
  j = degree of freedom of each of the joints
  f_i = degree of freedom of each of joints

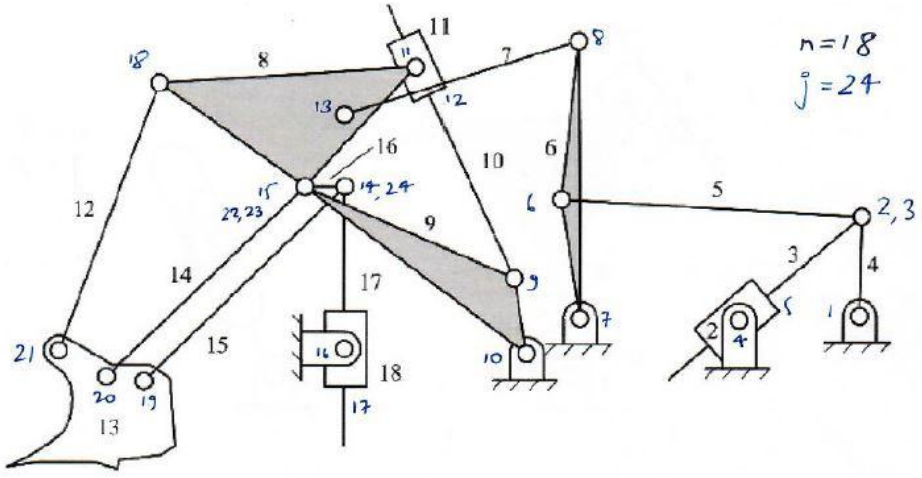
- **In Matlab, how can you come up with a way to code f_i?**
  -Using an array to construct f_i and passing the joint information as a string
  -Using Matlab table

3. Problems:

(1.15, 1.18, 1.27) Determine the mobility of the mechanisms below.



(a)



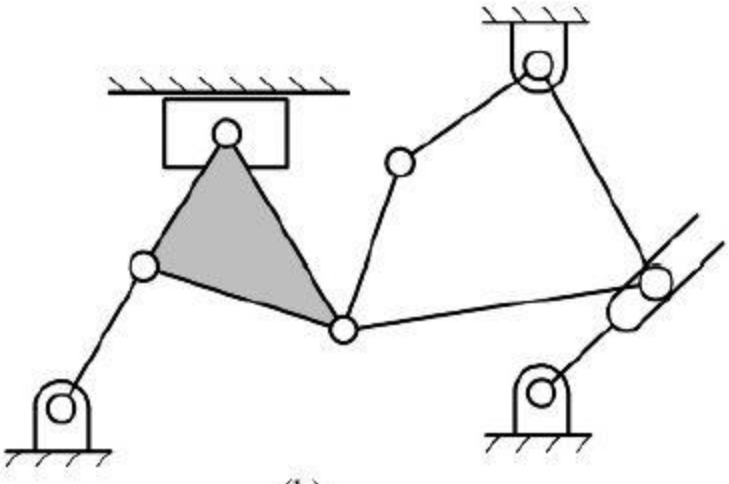
(a)

$$M = 3(n-1) - \sum_{i=1}^{j} (3 - f_i)$$

$$= 3(18-1) - \sum_{i=1}^{24} (3-1)$$

$$= 3 \times 17 - 24 \times 2$$

$$\therefore M = 3$$

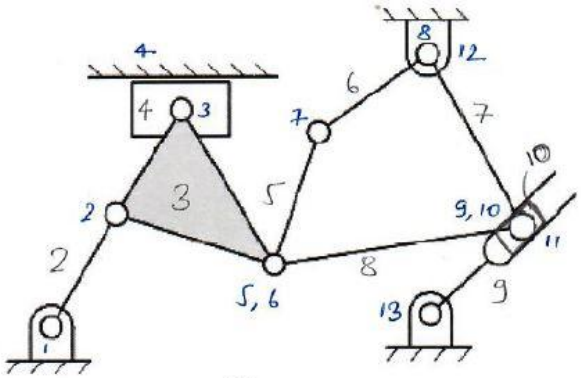


(b)

Joint #'12' is not counted in Recitation Session. My bad!

$n = 10$

$j = 13$



(b)

□ → Modification added by Dr. Ozemgad

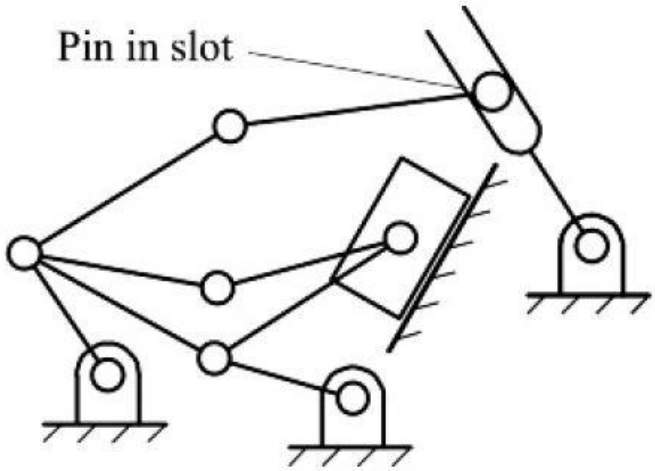
$$M = 3(n-1) - \sum_{i=1}^{j} (3 - f_i)$$

$$= 3(10-1) - \sum_{i=1}^{13} (3-1)$$

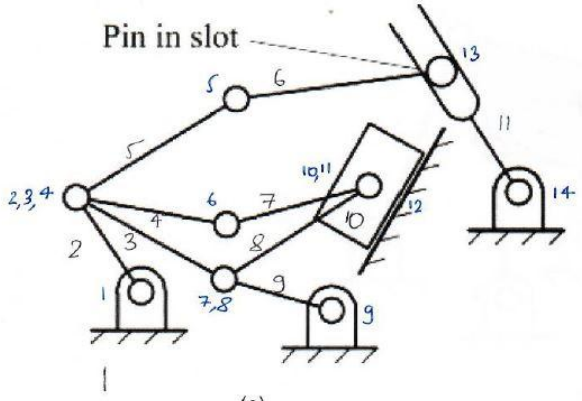
$$= 3 \times 9 - 13 \times 2$$

$$= 27 - 26$$

$$\therefore M = 1$$



(c)



(c)

$n = 11$

$j = 14$

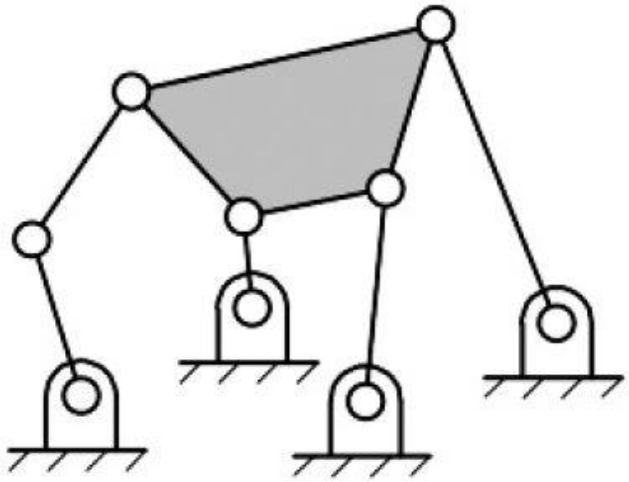
$$M = 3(n-1) - \sum_{i=1}^{j} (3 - f_i)$$

$$= 3(11-1) - \sum_{i=1}^{14} (3 - f_i)$$

$$= 3 \times 10 - 13(3-1) - 1(3-2)$$

$$= 30 - 26 - 1$$

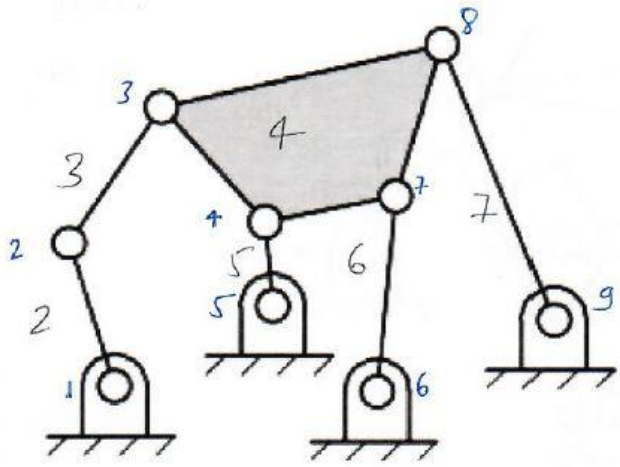
$$\therefore M = 3$$



(d)

$n = 7$

$j = 9$



1 (d)

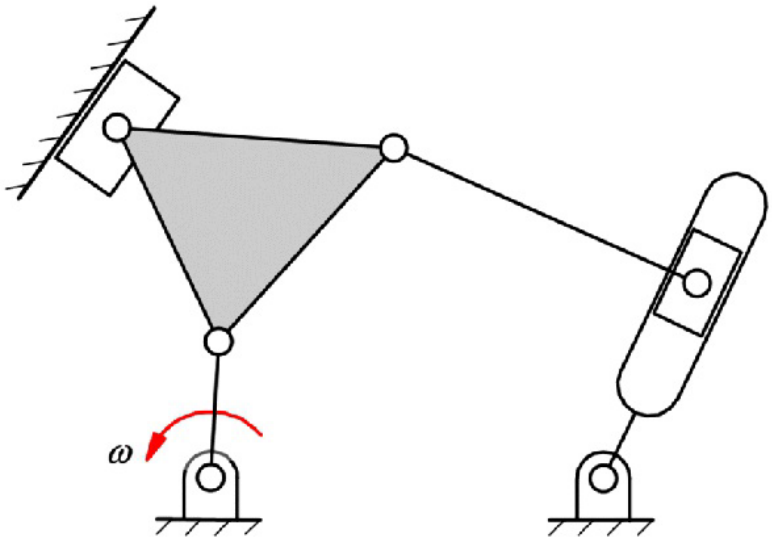
$$M = 3(n-1) - \sum_{i=1}^{j} (3 - f_i)$$

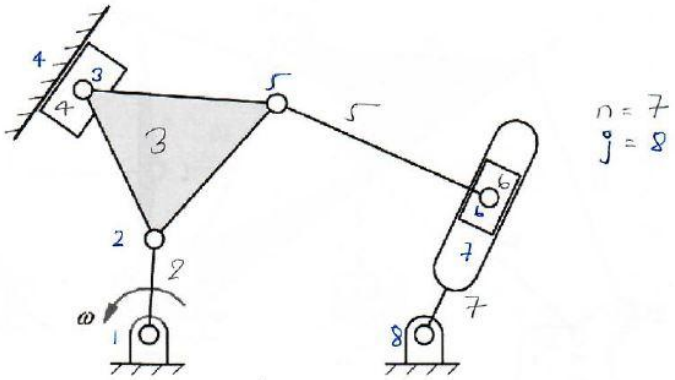
$$= 3(7-1) - \sum_{i=1}^{9} (3 - f_i)$$

$$= 3 \times 6 - 9(3-1)$$

$$\therefore M = 0$$

1.21 If position information is available for all points in the planar linkage shown in Figure below, can all of the velocities be determined uniquely if the value of ω is given? Explain your answer.





$$M = 3(n-1) - \sum_{i=1}^{j} (3-f_i)$$

$$= 3(7-1) - \sum_{i=1}^{8} (3-f_i)$$

$$= 18 - 8(3-1)$$

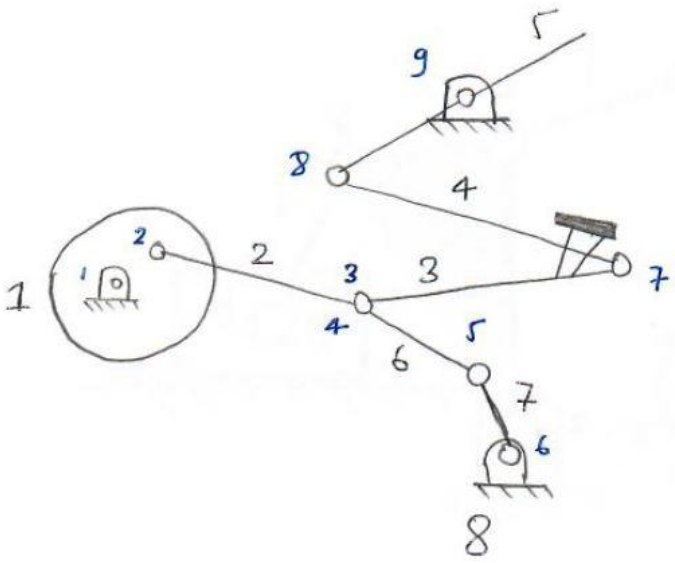
$$\therefore M = 18 - 16 = 2$$

Mobility of Mechanism is 2

Hence, two independent input variables must be given before all the velocities can be determined.

1.6 The figure below is an elliptical trainer machine. The mechanism is a planar linkage. There are linkages on both sides of the machine. The linkage on the right is a mirror image of the one on the left and the linkages are connected together so that they are always 180° out of phase with each other. For the left side, linkage identifies the moving joints and links. There is a handle that rotates about a fixed pivot. There is also a foot pedal that floats in that it is not connected to the frame of the machine.

a. Sketch the topology of the linkage.



b. How many links and joints are there?

Links=>8

Joints=>9

c. What is the mobility of the mechanism?

$$M = 3(n-1) - \sum_{i=1}^{j} (3-f_i)$$

$$= 3(8-1) - \sum_{i=1}^{9} (3-f_i)$$

$$M = 3\times 7 - 9(3-1)$$

$$\therefore M = 3$$

Bibliography:

- **Dr. Deemyad's Notes**
- **Kinematics and Dynamics of Machinery, 3rd edition, Chapter -1**

Miscellaneous:

If you fancy definitions:

- "Science is the study of what is; engineering is the creation of what is to be. This creative activity is design."(Waldron, Kinzel, 1999, p.2)
- Dynamics focuses on the **Analysis** of physical parameters of a provided system or component. Kinematics focuses mostly on the **Synthesis** of the mechanisms.
- **Analysis:** Techniques to determine the positions, velocities, and accelerations of points or members of mechanisms(Waldron, Kinzel, 1999, p.2) and their angular counterparts.
- **Synthesis:** Methods for mathematically the geometry of a mechanism to produce a desired set of positions and/or velocities or accelerations(Waldron, Kinzel, 1999, p.2)

ME 3320 Focus:

- Mechanism Design to produce the desired motion
- (Machine design focuses on the design of mechanism against failure)

Piece of Advice from TA as a past student of this class:

- The hw problems in this class involve design problems:
    - After you receive every hw problems, for each problem:
      Step-1: Understand what are the subproblems you need to solve
      Step 2: Have an idea/approach on how you can solve each of the subproblems
- Ask a lot of questions
- Most Important: Start working on the problems early