HW02

第02章 平面连杆机构

参考答案

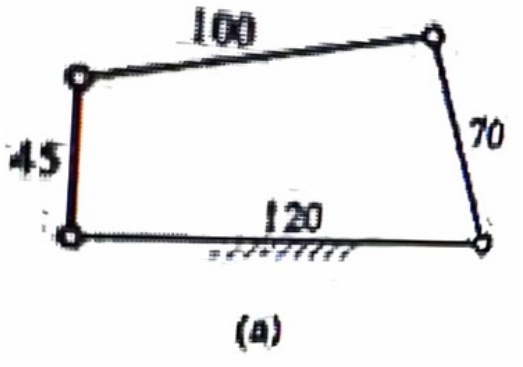
所有作业要求手写

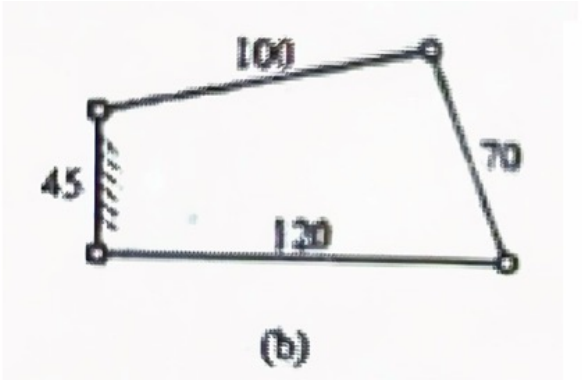
Autumn 2024

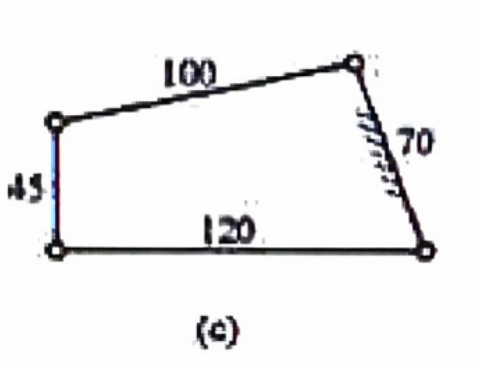
HW 02.1

- 根据长度关系判断图中三个铰链四杆机构：
  图 (a) 是 _____ 机构、图 (b) 是 _____ 机构、图 (c) 是 _____ 机构。

- Based on the length relationships, identify the three four-bar linkage mechanisms shown in the figure:
  Figure (a) is a _____ mechanism, Figure (b) is a _____ mechanism, and Figure (c) is a _____ mechanism.

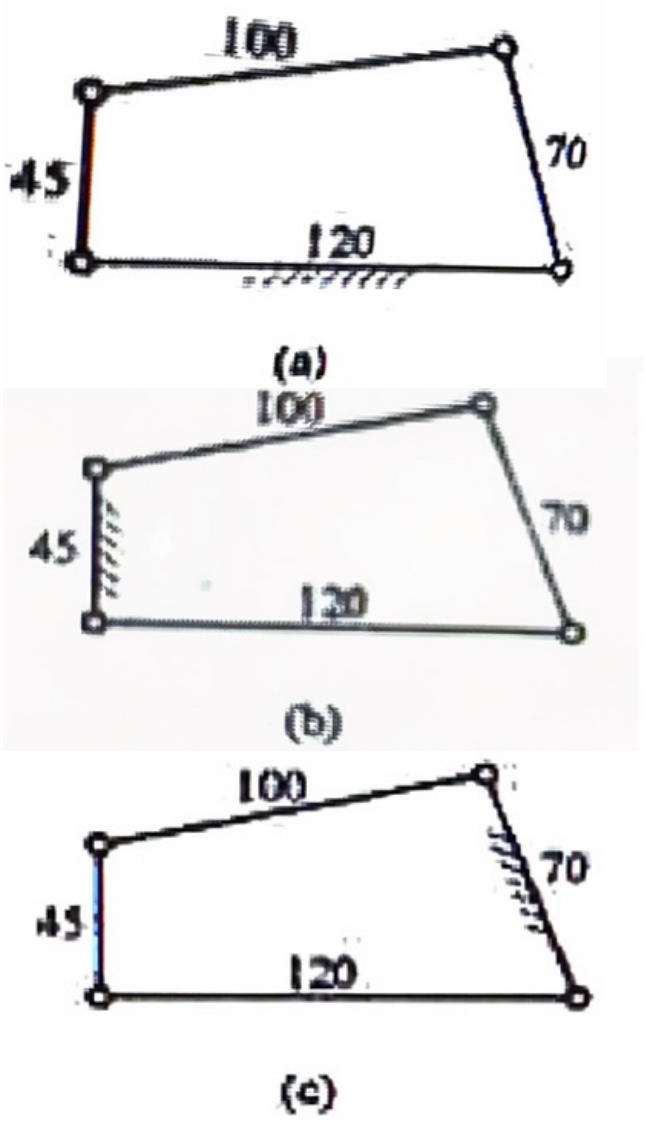






HW 02.1

- 解：三个机构中均有：45 + 120 < 100 + 70，即满足杆长条件。
  图(a) 最短杆为连架杆，故为曲柄摇杆机构；
  图(b) 最短杆为机架，故为双曲柄机构；
  图(c) 最短杆为连杆，故为双摇杆机构。



- Solution: In all three mechanisms, the inequality 45+120<100+70 holds, meaning the link lengths satisfy the necessary condition.

  In Figure (a), the shortest link is the coupler, so it is a crank-rocker mechanism;

  In Figure (b), the shortest link is the frame, so it is a double-crank mechanism;

  In Figure (c), the shortest link is the coupler, so it is a double-rocker mechanism.

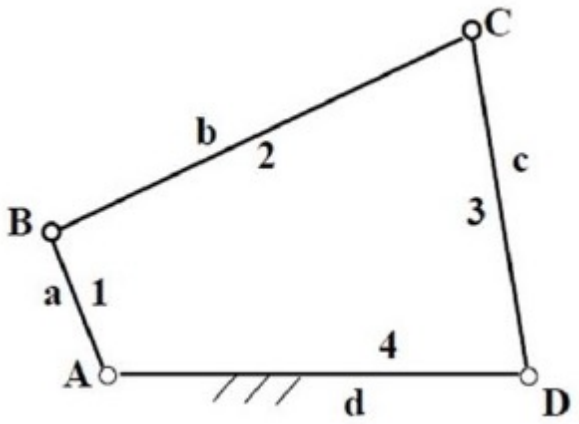
HW 02.2

- 如图所示，已知 $a = 240$ mm, $b = 600$ mm, $c = 400$ mm, $d = 500$ mm，

1) 当连杆 4 作为机架时，是否存在曲柄?
2) 是否可以选择不同的杆作为机架，以获得双曲柄机构和双摇杆机构？如何选择?
3) 若 a、b、c 三杆长度不变，取杆 4为机架，为得到曲柄摇杆机构，d 的取值范是多少?

- As shown in the figure, it is known that $a = 240$ mm, $b = 600$ mm, $c = 400$ mm, $d = 500$ mm,

1) When the lever 4 is used as a frame, is there a crank?
2) Can I choose different bars for the frame to get the double crank mechanism and double rocker mechanism ? How?
3) If the lengths of the three rods a, b, and c are unchanged, take rod 4 as the frame, and to obtain the crank and rocker mechanism, what should be the value range of d?



HW 02.2

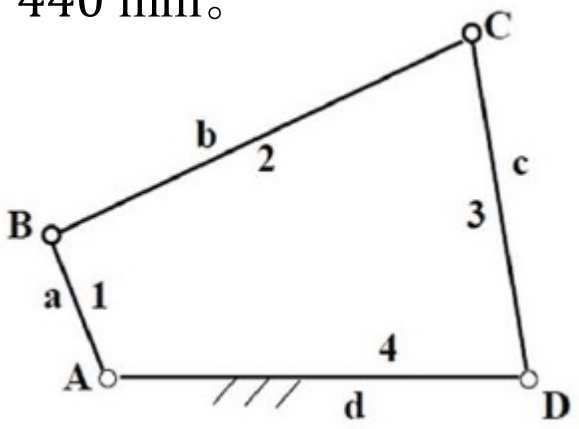
- 如图所示，已知 $a = 240$ mm, $b = 600$ mm, c =400 mm, $d = 500$ mm,

1) 平面四杆机构存在曲柄的条件是:
   1) 连架杆与机架中必有一杆为平面四杆机构中的最短杆
   2) 最短杆与最长杆的杆长之和应小于或等于其余两杆的杆长之和

   故有一个曲柄，杆1是曲柄。

2) 如果杆 1 是机架，该机构为双曲柄机构。
   如果杆 3 是机架，该机构为双摇杆机构。

3) 若杆 4 为最短杆，则为非曲柄摇杆，故 $d > 240$ mm。
   若杆 4 为最长杆，则 $a + d \leq b + c \rightarrow d \leq 760$ mm。
   若杆 4 为中间长度的杆，则 $a + b \leq c + d \rightarrow d \geq 440$ mm。
   因此，$440\text{ mm} \leq d \leq 760\text{ mm}$



HW 02.2

- As shown in the figure, it is known that a = 240 mm, b = 600 mm, c = 400 mm, d = 500 mm,

1) Grashof's condition: $L_{min} + L_{max} < Sum$ of the remaining two stroke lengths.

   The shortest rod is the connecting rod or frame.

   There is a crank, and rod 1 is crank.

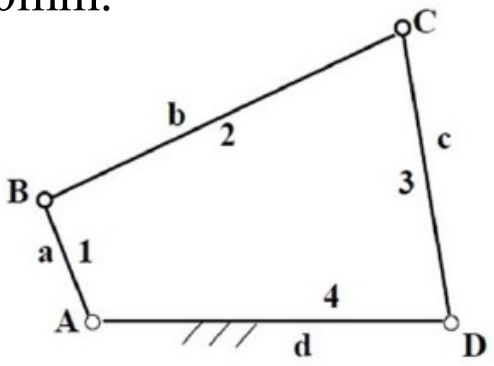
2) If rod 1 is frame, it is double-crank. If rod 3 is frame, it is double-rocker.

3) If rod 4 is the shortest rod, it is not crank-rocker, so d > 240mm.

   If rod 4 is the longest rod, $a + d \le b + c \rightarrow d \le 760$ mm.

   If rod 4 is the middle rod, $a + b \le c + d \rightarrow d \ge 440$ mm.

   Therefore, $440 \le d \le 760$.



HW 02.3

- 如图所示为偏置曲柄滑块机构。
  曲柄 1 和连杆 2 的长度分别为 201.7 *mm* 和 605.2 *mm*，偏距 $e = 325.6mm$。

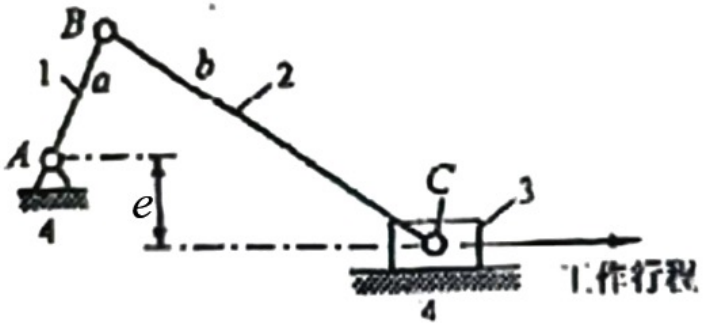
1) 若滑块 3 向右运动为机构的工作行程（慢行程），试确定曲柄 1 的转动方向；

2) 求该机构的最小传动角 γ，并作图画出其对应的位置。

- The figure shows an offset crank-slider mechanism.
  The lengths of crank 1 and connecting rod 2 are 201.7 *mm* and 605.2 *mm*, respectively, with an offset distance of $e = 325.6$ *mm*

1) If slider 3 moves to the right during the working stroke (slow stroke) of the mechanism, determine the rotation direction of crank 1.

2) Find the minimum transmission angle γ of the mechanism and draw its corresponding position.

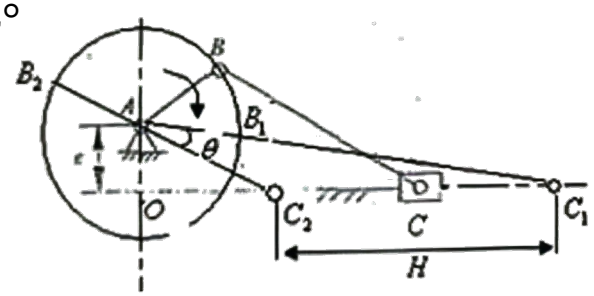


HW 02.3

1) 由于机构的急回特性，即空回行程的平均速度小于工作行程的平均速度，应使曲柄 1 为顺时针转动，如图所示。

2) 如图所示，当曲柄 AB 与工作行程垂直，处于图示 $AB'C'$ 位置时，传动角最小。由几何关系知:

$$\gamma_{\min} = \arccos\frac{a+e}{b} = 29.4°$$



1) Due to the quick-return characteristic of the mechanism, where the average speed during the return stroke is lower than that during the working stroke, crank 1 should rotate in a clockwise direction, as shown in the figure

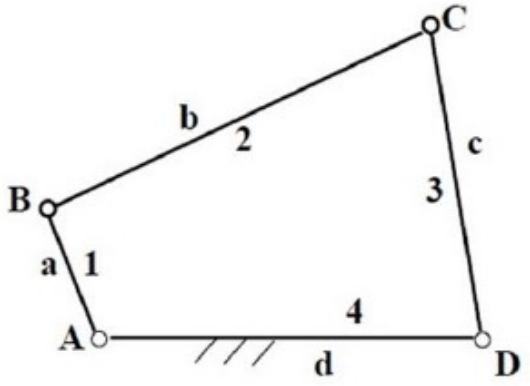
2) As shown in the figure, when crank AB is perpendicular to the working stroke, at position AB′C′AB'C'AB′C′ as illustrated, the transmission angle is at its minimum. From the geometric relationship, we know:

$$\gamma_{\min} = \arccos\frac{a+e}{b} = 29.4°$$

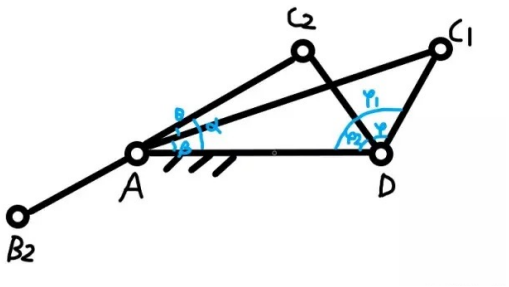
HW 02.4

- 已知四杆机构 $L_1 = 28$ mm, $L_2 = 52$ mm, $L_3 = 50$ mm, $L_4 = 72$ mm,当取 4 杆为机架时，求该机构的极位夹角 θ、最小传动角 γ 和行程速度变化系数 K。

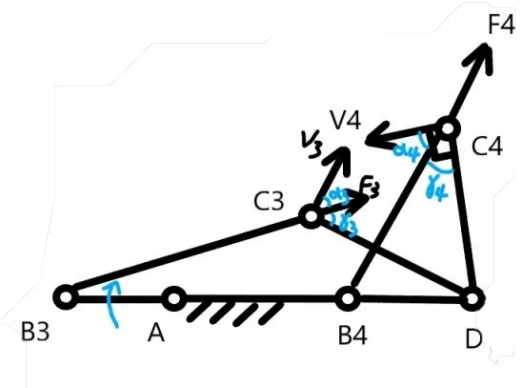
- It is known that the 4-pole mechanism $L_1 = 28$ mm, $L_2 = 52$ mm, $L_3 = 50$ mm, $L_4 = 72$ mm, when the 4-rod is taken as a rack, find crank angle θ between extreme positions , the minimum transmission angle γ and the coefficient of variation of travel speed of the mechanism K.



HW 02.4



- $\theta = \angle C_2AD - \angle C_1AD \approx 37.95^\circ\text{-}19.39^\circ\text{=}18.56^\circ$
- $K = \frac{180°+\theta}{180°-\theta} = \frac{198.56}{161.44} = 1.23$



- $\gamma = \min\{\delta_{min}, 180° - \delta_{max}\}$
- $\delta_{\max} = \angle B_3C_3D,$
- $180° - \delta_{max} \approx 22.74^\circ$
- $\delta_{\min} = \angle B_4C_4D \approx 51.06^\circ$
- $180° - \delta_{max} < \delta_{\min}$
- $\gamma = 180° - \delta_{max} = 22.7^\circ$

Thank you~

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附加题 02.1

- 目前四足机器人腿部结构主要采用平面四连杆与串联两种构型，请问平面连杆机构在此的优势有哪些？

- At present, the leg structure of quadruped robot mainly adopts two configurations of plane four-bar linkage and series linkage. What are the advantages of the plane linkage mechanism in this condition?

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附加题 02.1

1) 减小腿部机构转动惯量，减小对电机的负载
2) 外形美观、节约空间，避免膝盖臃肿
3) 便于布线、走线

1) Reduce the inertia of the leg mechanism, reduce the load on the motor
2) Look Good, save space, and avoid bulky knees
3) Easy wiring

关于附加题的批改与答疑，请联系：
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