PROBLEM 2-21

Statement: Find the mobility of the mechanisms in Figure P2-4.

Solution: See Figure P2-4 and Mathcad file P0221.

1. Use equation 2.1c (Kutzbach's modification) to calculate the mobility.

a. This is a basic fourbar linkage. The input is link 2 and the output is link 4. The cross-hatched pivot pins at *O*2 and *O*4 are attached to the ground link (1).

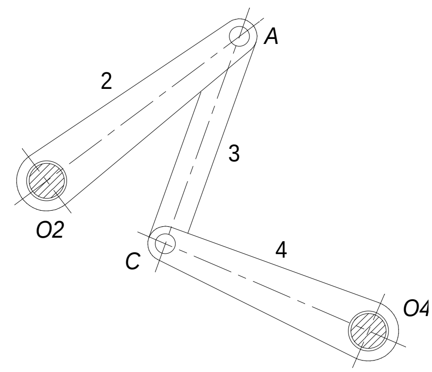
Number of links $L := 4$

Number of full joints $J_1 := 4$

Number of half joints $J_2 := 0$

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

$$M = 1$$



b. This is a fourbar linkage. The input is link 2, which in this case is the wheel 2 with a pin at *A*, and the output is link 4. The cross-hatched pivot pins at *O*2 and *O*4 are attached to the ground link (1).

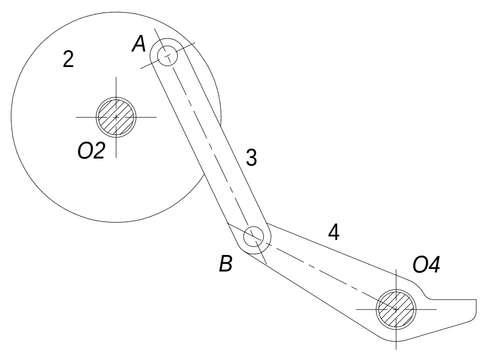
Number of links $L := 4$

Number of full joints $J_1 := 4$

Number of half joints $J_2 := 0$

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

$$M = 1$$



c. This is a 3-cylinder, rotary, internal combustion engine. The pistons (sliders) 6, 7, and 8 drive the output crank (2) through piston rods (couplers 3, 4, and 5). There are 3 full joints at the crank where rods 3, 4and 5 are pinned to crank 2. The cross-hatched crank-shaft at *O*2 is supported by the ground link (1) through bearings.

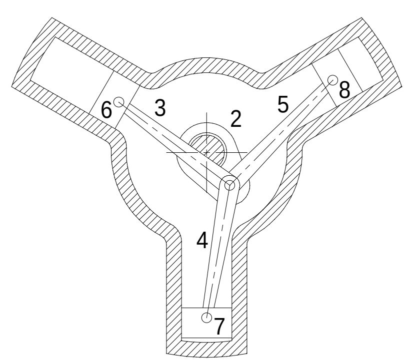
Number of links $L := 8$

Number of full joints $J_1 := 10$

Number of half joints $J_2 := 0$

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

$$M = 1$$



d. This is a fourbar linkage. The input is link 2, which in this case is a wheel with a pin at *A*, and the output is the vertical member on the coupler, link 3. Since the lengths of links 2 and 4 (O_2A and O_4B) are the same, the coupler link (3) has curvilinear motion and *AB* remains parallel to O_2O_4 throughout the cycle. The cross-hatched pivot pins at O_2 and O_4 are attached to the ground link (1).

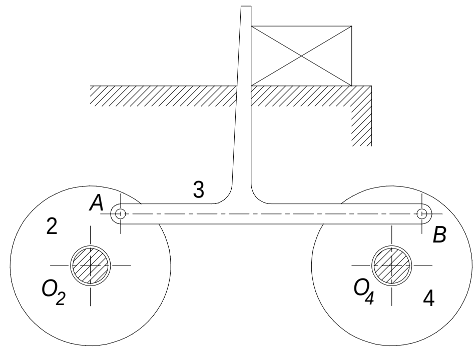
Number of links $L := 4$

Number of full joints $J_1 := 4$

Number of half joints $J_2 := 0$

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

$$M = 1$$



e. This is a fourbar linkage with an output dyad. The input (rocker) is link 2 and the output (rocker) is link 8. Links 5 and 6 are redundant, i.e. the mechanism will have the same motion if they are removed. The input fourbar consists of links 1, 2, 3, and 4. The output dyad consists of links 7 and 8. The cross-hatched pivot pins at *O*2, *O4* and *O*8 are attached to the ground link (1). In the calculation below, the redundant links and their joints are not counted (subtract 2 links and 4 joints from the totals).

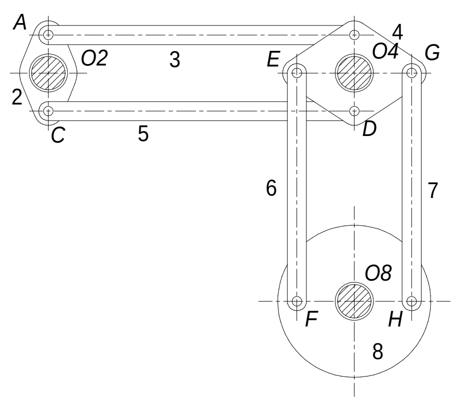
Number of links $L := 6$

Number of full joints $J_1 := 7$

Number of half joints $J_2 := 0$

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

$$M = 1$$



f. This is a fourbar offset slider-crank linkage. The input is link 2 (crank) and the output is link 4 (slider block). The cross-hatched pivot pin at *O*2 is attached to the ground link (1).

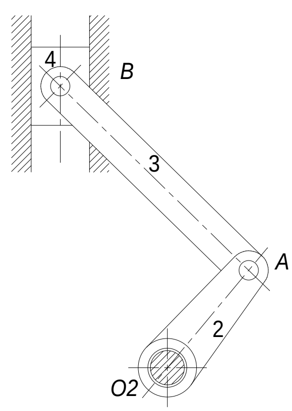
Number of links $L := 4$

Number of full joints $J_1 := 4$

Number of half joints $J_2 := 0$

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

$$M = 1$$



g. This is a fourbar linkage with an alternate output dyad. The input (rocker) is link 2 and the outputs (rockers) are links 4 and 6. The input fourbar consists of links 1, 2, 3, and 4. The alternate output dyad consists of links 5 and 6. The cross-hatched pivot pins at $O2$, $O4$ and $O6$ are attached to the ground link (1).

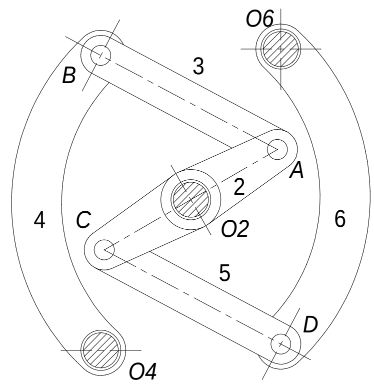
Number of links $L := 6$

Number of full joints $J_1 := 7$

Number of half joints $J_2 := 0$

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

$$M = 1$$



h. This is a ninebar mechanism with three redundant links, which reduces it to a sixbar. Since this mechanism is symmetrical about a vertical centerline, we can split it into two mirrored mechanisms to analyze it. Either links 2, 3 and 5 or links 7, 8 and 9 are redundant. To analyze it, consider 7, 8 and 9 as the redundant links. Analyzing the ninebar, there are two full joints at the pins A, B and C for a total of 12 joints.

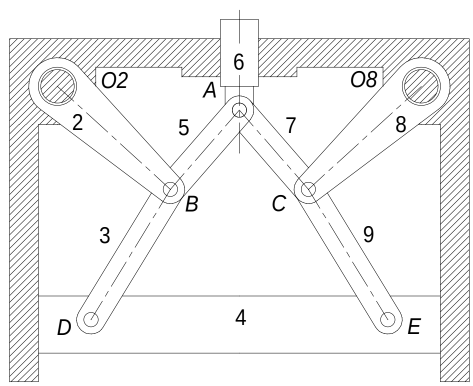
Number of links $L := 9$

Number of full joints $J_1 := 12$

Number of half joints $J_2 := 0$

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

$$M = 0$$



The result is that this mechanism seems to be a structure. By splitting it into mirror halves about the vertical centerline the mobility is found to be 1. Subtract the 3 redundant links and their 5 (6 minus the joint at A) associated joints to determine the mobility of the mechanism.

Number of links $L := 9 - 3$

Number of full joints $J_1 := 12 - 5$

Number of half joints $J_2 := 0$

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

$$M = 1$$