

**PROBLEM 2-1**

**Statement:** Find three (or other number as assigned) of the following common devices. Sketch careful kinematic diagrams and find their total degrees of freedom.

- An automobile hood hinge mechanism
- An automobile hatchback lift mechanism
- An electric can opener
- A folding ironing board
- A folding card table
- A folding beach chair
- A baby swing
- A folding baby walker
- A fancy corkscrew as shown in Figure P2-9
- A windshield wiper mechanism
- A dump-truck dump mechanism
- A trash truck dumpster mechanism
- A pickup tailgate mechanism
- An automobile jack
- A collapsible auto radio antenna

**Solution:** See Mathcad file P0201.

Equation 2.1c is used to calculate the mobility (*DOF*) of each of the models below.

- An automobile hood hinge mechanism.

The hood (3) is linked to the body (1) through two rocker links (2 and 4).

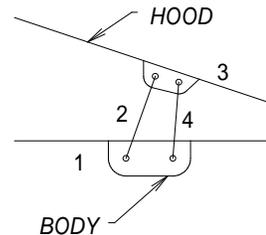
$$\text{Number of links} \quad L := 4$$

$$\text{Number of full joints} \quad J_1 := 4$$

$$\text{Number of half joints} \quad J_2 := 0$$

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

$$M = 1$$



- An automobile hatchback lift mechanism.

The hatch (2) is pivoted on the body (1) and is linked to the body by the lift arm, which can be modeled as two links (3 and 4) connected through a translating slider joint.

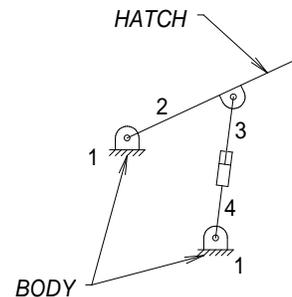
$$\text{Number of links} \quad L := 4$$

$$\text{Number of full joints} \quad J_1 := 4$$

$$\text{Number of half joints} \quad J_2 := 0$$

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

$$M = 1$$



- An electric can opener has 2 *DOF*.

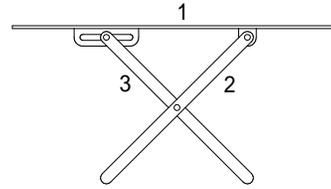
- A folding ironing board.

The board (1) itself has one pivot (full) joint and one pin-in-slot sliding (half) joint. The two legs (2 and 3) have a common pivot. One leg connects to the pivot joint on the board and the other to the slider joint.

Number of links  $L := 3$   
 Number of full joints  $J_1 := 2$   
 Number of half joints  $J_2 := 1$

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

$$M = 1$$



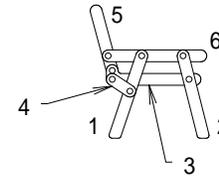
- e. A folding card table has 7 *DOF*: One for each leg, 2 for location in *xy* space, and one for angular orientation.
- f. A folding beach chair.

The seat (3) and the arms (6) are ternary links. The seat is linked to the front leg (2), the back (5) and a coupler link (4). The arms are linked to the front leg (2), the rear leg (1), and the back (5). Links 1, 2, 4, and 5 are binary links. The analysis below is appropriate when the chair is not fully opened. When fully opened, one or more links are prevented from moving by a stop. Subtract 1 *DOF* when forced against the stop.

Number of links  $L := 6$   
 Number of full joints  $J_1 := 7$   
 Number of half joints  $J_2 := 0$

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

$$M = 1$$



- g. A baby swing has 4 *DOF*: One for the angular orientation of the swing with respect to the frame, and 3 for the location and orientation of the frame with respect to a 2-D frame.
- h. A folding baby walker has 4 *DOF*: One for the degree to which it is unfolded, and 3 for the location and orientation of the walker with respect to a 2-D frame.
- i. A fancy corkscrew has 2 *DOF*: The screw can be rotated and the arms rotate to translate the screw.
- j. A windshield wiper mechanism has 1 *DOF*: The position of the wiper blades is defined by a single input.
- k. A dump-truck dump mechanism has 1 *DOF*: The angle of the dump body is determined by the length of the hydraulic cylinder that links it to the body of the truck.
- l. A trash truck dumpster mechanism has 2 *DOF*: These are generally a rotation and a translation.
- m. A pickup tailgate mechanism has 1 *DOF*:
- n. An automobile jack has 4 *DOF*: One is the height of the jack and the other 3 are the position and orientation of the jack with respect to a 2-D frame.
- o. A collapsible auto radio antenna has as many *DOF* as there are sections, less one.