DS-1: Modeling and simulation of a scissor lift mechanism in MATLAB

Description

Scissor lift is a type of mechanism that allows for vertical displacement of some load, through the use of linked, folding supports, in a crisscross "X" pattern, referred to as a pantograph (or, simply, a scissor mechanism). Scissor lifts are widely used in industrial applications, and also form a staple design element in competitive robotics. Each arm of the crosses is called a 'scissor arm' or 'scissor member'. The upward motion is produced by the application of force, by some actuator (usually hydraulic, pneumatic, or mechanical), to the outside of the one set of supports, elongating the crossing pattern, and propelling the load vertically. A Scissor lift mechanism under application is represented in Figure 1.

Figure 1: A six stage hydraulic scissor lift mechanism

Objective

The objective of this assignment will be to design a two stage scissor lift mechanism in MATLAB. The tasks will be carried out step-by-step starting from defining the forward kinematics equation till the 3D model of the mechanism. The final task should represent a mechanism as depicted in Figure 4.

Task-1

The first task will begin with deriving the forward kinematics equation for the mechanism. The output for the results of Task-1 should resemble Figure 2. The origin **o** of the mechanism can be positioned at [0,0]. The hydraulic stroke is accomplished in **oa** and the stroke length is given by ρ. The two stage scissor lift mechanism comprises of 4 links which are **oc**, **ad**, **dg** and **cf**. The hinge points are represented by circular dots in Figure 2. For deriving the forward kinematics equation as well as the position of each hinge point, the links must be subdivided as

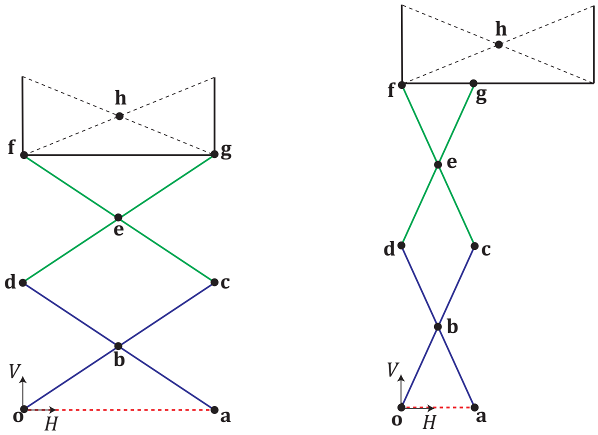

Figure 2: Coordinates of hinge points for planar modeling in MATLAB

$$\|\mathbf{oa}\| = \rho, \|\mathbf{ob}\| = \|\mathbf{ba}\| = L_1 \tag{1}$$

$$\|\mathbf{cb}\| = \|\mathbf{db}\| = L_2 \tag{2}$$

$$\|\mathbf{ed}\| = \|\mathbf{ec}\| = L_3 \tag{3}$$

$$\|\mathbf{ge}\| = \|\mathbf{fe}\| = L_4 \tag{4}$$

By fixing each values of Eqns. 1 to 4 as 20 mm, construct the mechanism in MATLAB and simulate it by varying ρ from 10 to 30 mm. The x-coordinate of **b** and **e** is always at the mid-position of **oa**. In order to construct the platform, the rotation matrices must be used with respect to centroid position **h**. Note that the platform is fixed only at **f** and the other end is free to slide. The length of the rigid platform can be taken as the maximum value of ρ and the width can be taken as 2 mm.

The file for task-1 can be saved as: **Task-1.m**. Provide the author name at the top of code and comment wherever necessary.

Task-2

Each links constructed from Task-1 must be converted as rectangular blocks using the z-rotation matrix. The centroid positions must be identified and rotation angles must be applied carefully such that the profile remains uniform during each stroke. The output must resemble something similar to Figure 3.

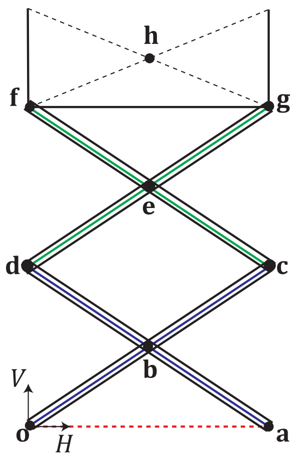

Figure 3: Conversion of links to rectangular blocks

The file for task-2 can be saved as: **Task-2.m**.

Task-3

The 3D modeling must be performed. Each links have a thickness of 0.5 mm. In order to construct the 3D model, the *fill*3 option can be used and it is not necessary to derive mathematical relations. In MATLAB, by default $x - z$ is the construction plane and y will be the extrusion axis. The *plot*3 command is used to join all necessary links. The second set of links is at an offset of 10 mm and this could be seen in Figure 4. Simulate the mechanism back and forth for stroke lengths of 10–30 mm,30–10 mm,10–20 mm,20–10 mm,10–25 mm,25–10 mm, 10–30 mm & 30–10 mm. The hinges can be extruded using *cylinder* function in MATLAB. The file for task-3 can be saved as: **Task-3.m**.

Additional

1. Using the azimuth,elevation view options and *subplot* function of MATLAB, generate and simulate the front, side and isometric views for the mechanism in the third angle projection.

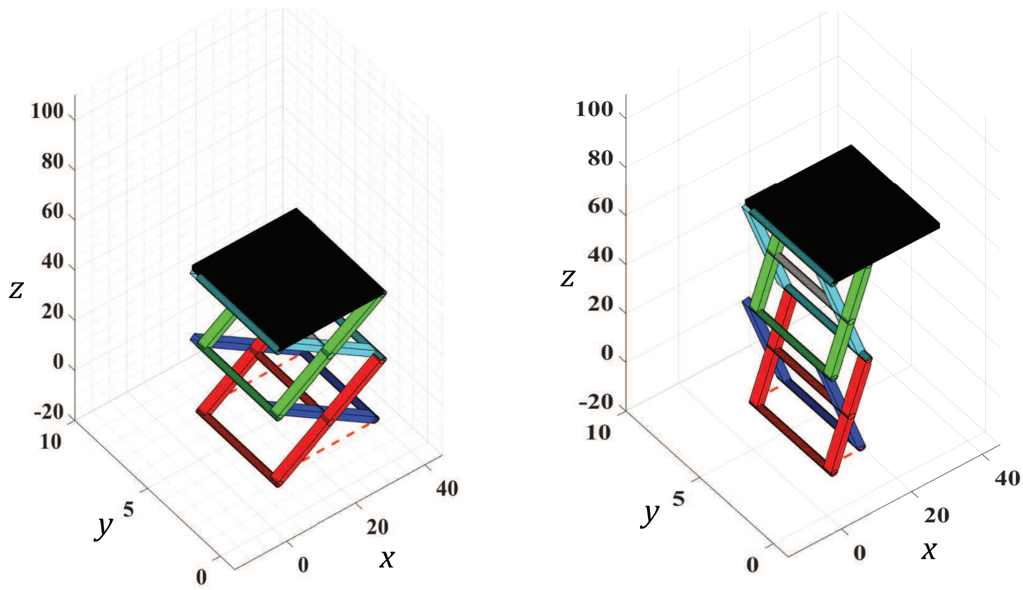

Figure 4: Two stage scissor lift mechanism in MATLAB under fully extended (left) and retracted positions (right)

Submission

1. The deadline for submission is 28.03.2020 (12:00 PM) on Hippocampus portal. The three .m files and the report can be zipped and submitted as "Student name.zip".
2. A report must be written providing the direct kinematics equation for the mechanism, rectangular links equation, angular positions of each hinge points and final model.
3. Using functions will reduce the lines of codes and adds credibility. Refer to the crank.m file for clarity.
4. To understand working of a function in MATLAB, type *help* "*functionname*″ in the command window
5. These functions can be useful for completion: *plot*, *plot*3, *scatter*, *scatter*3, *fill*3, *cylinder*, *surf*.
6. Do comment the codes wherever necessary and for better grades