Exercise 6:
Kinematic analysis of 2D and 3D structures

For each of the four proposed structures, perform a kinematic analysis.

1. Draw the **kinematic diagram** of the structure. Include the joints, the fixed ground, and the output of the mechanism. Also, the input if applicable.

2. Draw the **topologic diagram** of the structure, i.e. the unfolded equivalent diagram of the structure.

3. On the topologic diagram, count the number of **kinematic loops**. Also, count the number of **segments** and **joints**. Check the number of loops by applying the formula:
$$L = k - n + 1$$
With L the number of loops, k the number of joints and n the number of segments (including the fixed frame).

4. Specify if the **planar (2D) or volumetric (3D)** analysis assumptions apply.

5. Identify the number of **external and internal degrees of freedom** (**DOFe** and **DOFi**)

6. Count the number of **internal mobilities**, i.e. sum the DOF of each joint of the structure. NB: stay at the joint level, e.g. a parallel blade stage counts for 1 DOF.

7. Determine the number of **overconstraints OC** by applying the mobility equation:
$$DOF_e + DOF_i = \sum Mo - 3L + OC \qquad \text{in 2D}$$
$$DOF_e + DOF_i = \sum Mo - 6L + OC \qquad \text{in 3D}$$

8. Identify the location and direction of the **overconstraints**.

Structures to be analyzed:

13-Hinge stage:

- The fixed pivot of the lever (fulcrum) is a punctual pivot.
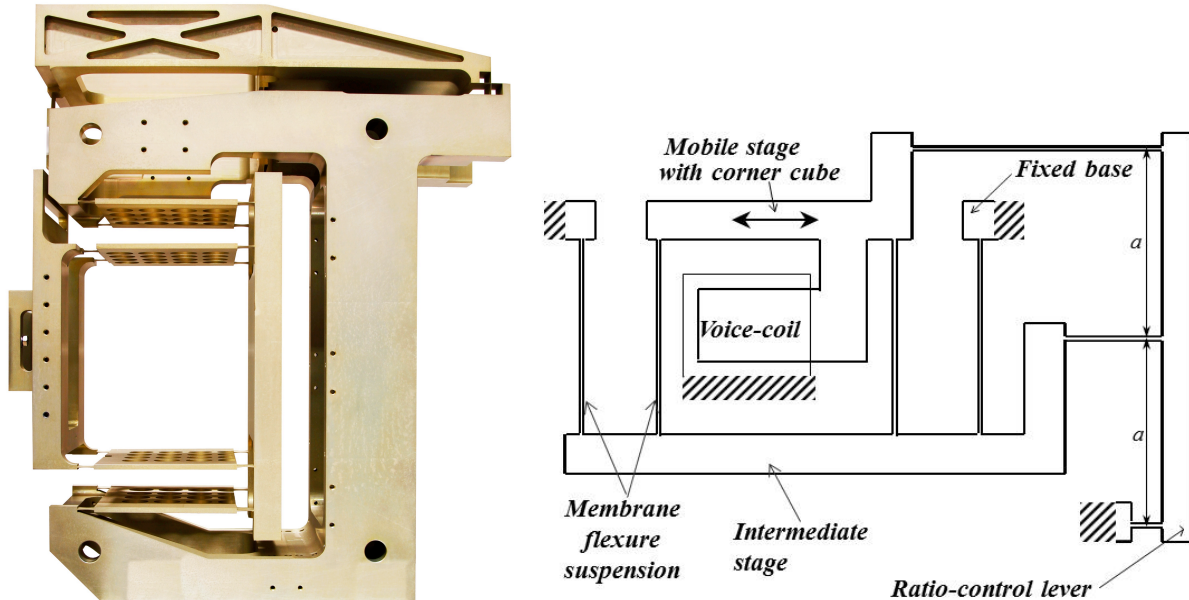- On the Fig. 1 left, two coaxial pivots count for one pivot.

Figure 1: 13-Hinge stage

Compliant Rotation Reduction Mechanism:

- The crossed blades pivots and the parallel blade mobilities are joints with a mobility number of one.
- Do not forget to count the output linking segment. It does not appear on the Fig. 2 left.
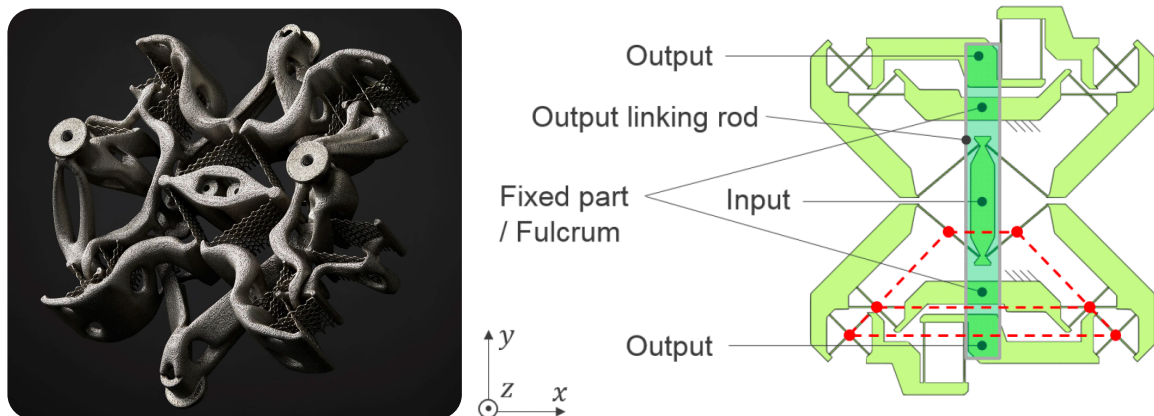

Figure 2 : Compliant Rotation Reduction Mechanism

Serial XY stage:

- The fixed parts of the two slabs are linked rigidly.
- The output parts of the two slabs are linked rigidly.
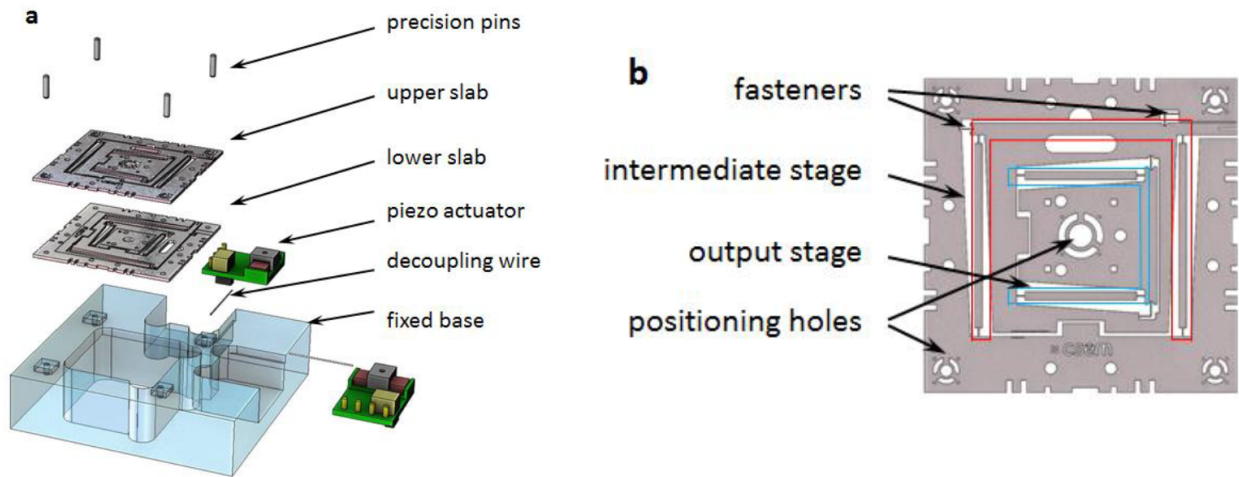- Do not consider the piezo actuators and the decoupling wires.

Figure 3 : Serial XY stage

Micro-vibration Isolation Platform:

- The lower half strut has one DOF in translation. (consider it has no overconstraints and no internal DOFi)
- Consider the planar joint to be compliant in axial torsion (i.e. has having 3 external DOFe and no internal DOFi)
- Consider the gimbal to be rigid in lateral translation and in axial torsion.
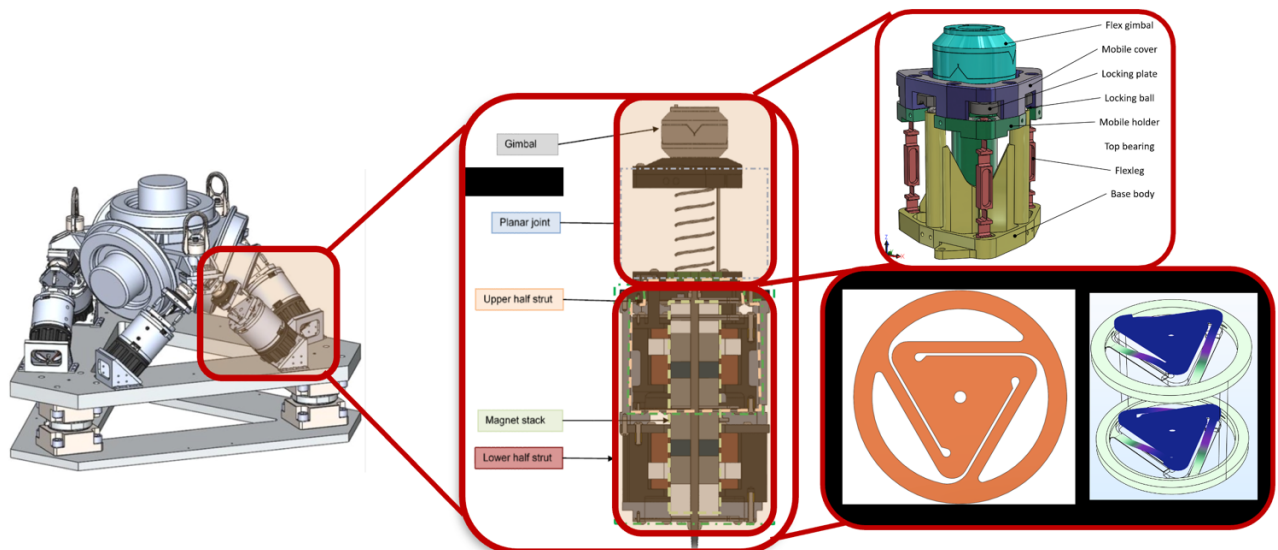- All the joints of the mechanism are encompassed within the six struts (legs) arranged in a hexapod configuration.

Figure 4: Micro-vibration Isolation Platform