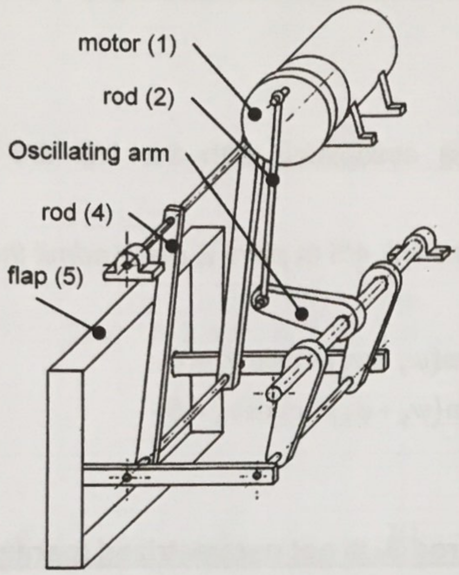
INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

SCAN 2nd – duration 1h
Monday 18th December 2018

SWELL SIMULATOR (*the return!*)



Schematics of the swell simulator

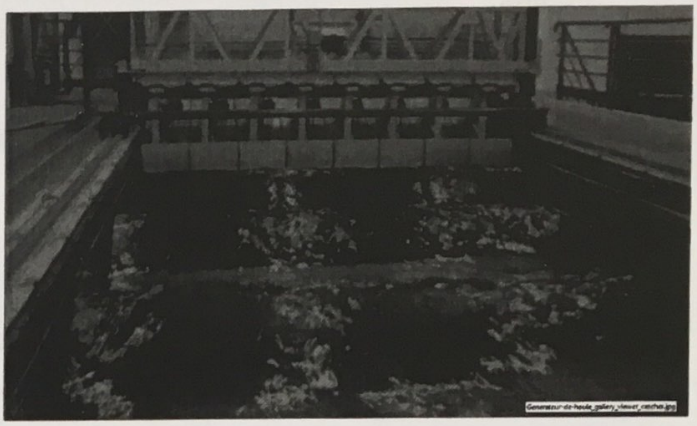


Photo of an actual swell simulator

<u>The planar model of swell simulator</u> is shown in Figure 1 and comprises:

- A disc S_1, attached to the motor axle and connected to the ground S_0 by a revolute joint of axis $(O,\vec{y})$
  Parameter for motion 1/0 : $\psi_1 = (\vec{x}_0,\vec{x}_1) = (\vec{z}_0,\vec{z}_1)$
- A rod S_2 connected to disc S_1 by a revolute joint of axis $(A,\vec{y})$
  Parameter for motion 2/1 : $\psi_2 = (\vec{x}_1,\vec{x}_2) = (\vec{z}_1,\vec{z}_2)$
- An oscillating arm S_3 connected to the ground S_0 by a revolute joint of axis $(C,\vec{y})$
  Parameter for motion 3/0 : $\psi_3 = (\vec{x}_0,\vec{x}_3) = (\vec{z}_0,\vec{z}_3)$
- A rod S_4 connected to the ground S_0 by a revolute joint of axis $(F,\vec{y})$
  Parameter for motion 4/0 : $\psi_4 = (\vec{x}_0,\vec{x}_4) = (\vec{z}_0,\vec{z}_4)$
- A flap S_5 connected to the oscillating arm S_3 by a revolute joint of axis $(D,\vec{y})$
  Parameter for motion 5/3 : $\psi_5 = (\vec{x}_3,\vec{x}_5) = (\vec{z}_3,\vec{z}_5)$

Moreover:

- rod S_2 is connected to the oscillating arm S_3 by a revolute joint of axis $(B,\vec{y})$ (*no parameter*)
- rod S_4 is connected to flap S_5 by a revolute joint of axis $(E,\vec{y})$ (*no parameter*).

Part I : Frame definition / parameters – Constraint equations - Mobility

I.1 - Draw the change of basis diagrams associated with motions 2/1, 5/3, 2/0 and 5/0.

I.2 - Draw the graph of links.

I.3 - Develop the constraint equation(s) associated with the link 2/3 with no parameter at point B.

The constraint equations associated with the link 4/5 at point E read (*admit the result*):

$$x_F - x_C - \ell_4 \sin\psi_4 - a\cos(\psi_5 + \psi_3) + c\sin\psi_3 = 0$$
$$z_F - z_C - \ell_4 \cos\psi_4 + a\sin(\psi_5 + \psi_3) + c\cos\psi_3 = 0$$

I.4 - Give the mobility of the mechanism

I.5 - **Assuming now that the motion of rod S_4 is not parametrized (parameter ψ_4 is not defined any longer)**, draw the new graph of links, give the new constraint equation (vector form without developing the analytical expressions) and derive the system mobility.

Partie II : Kinematics

II.1 - Specify the nature of motion 1/0 and give the vector coordinates of its kinematic screw at point A (**results expressed in the coordinate system 1**)

II.2 - Calculate the acceleration vector $\vec{A}^0(A)$ (**results expressed in the coordinate system 1**)

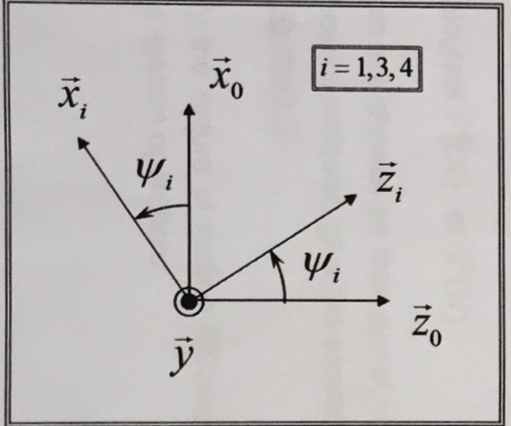
II.3 - Knowing that $\vec{V}^0(D) = -c\dot{\psi}_3\vec{x}_3$, calculate $\vec{V}^0(N)$ et $\vec{A}^0(N)$

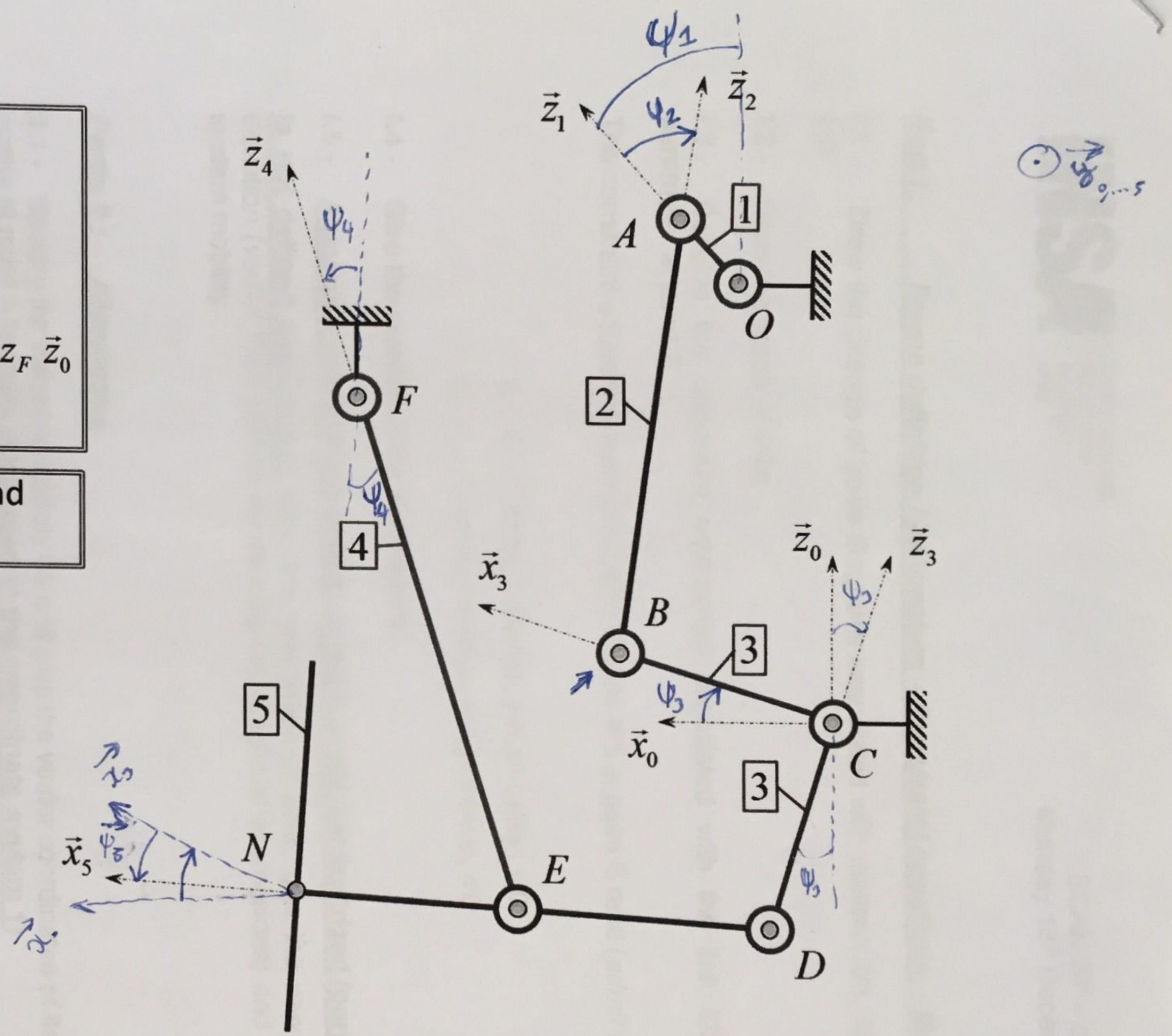
II.4 - The dimensions of the mechanism are chosen so that $\psi_3 + \psi_5 \approx 0$ and ψ_3 is a small angle ($\cos\psi_3 \approx 1, \sin\psi_3 \approx \psi_3$). In these conditions, give the expression of $\vec{V}^0(N)$ (**results expressed in the coordinate system 0**)

II.5 – If, in addition, $\psi_3\dot{\psi}_3 << \dot{\psi}_3$, specify the nature of motion 5/0 and explain why such a condition is interesting with regard to the system operation.

$$\overrightarrow{OA} = e\,\vec{z}_1 \qquad \overrightarrow{AB} = -\ell_2\,\vec{z}_2$$
$$\overrightarrow{BC} = -c\,\vec{x}_3 \qquad \overrightarrow{CD} = -c\,\vec{z}_3$$
$$\overrightarrow{DE} = a\,\vec{x}_5 \qquad \overrightarrow{EF} = \ell_4\,\vec{z}_4$$
$$\overrightarrow{DN} = d\,\vec{x}_5 \qquad \overrightarrow{OF} = x_F\,\vec{x}_0 + z_F\,\vec{z}_0$$
$$\overrightarrow{OC} = x_C\,\vec{x}_0 + z_C\,\vec{z}_0$$

All the lengths above are positive and constant





5/8 = 5/7+3/0

Figure 1 – Kinematic model of the swell simulator