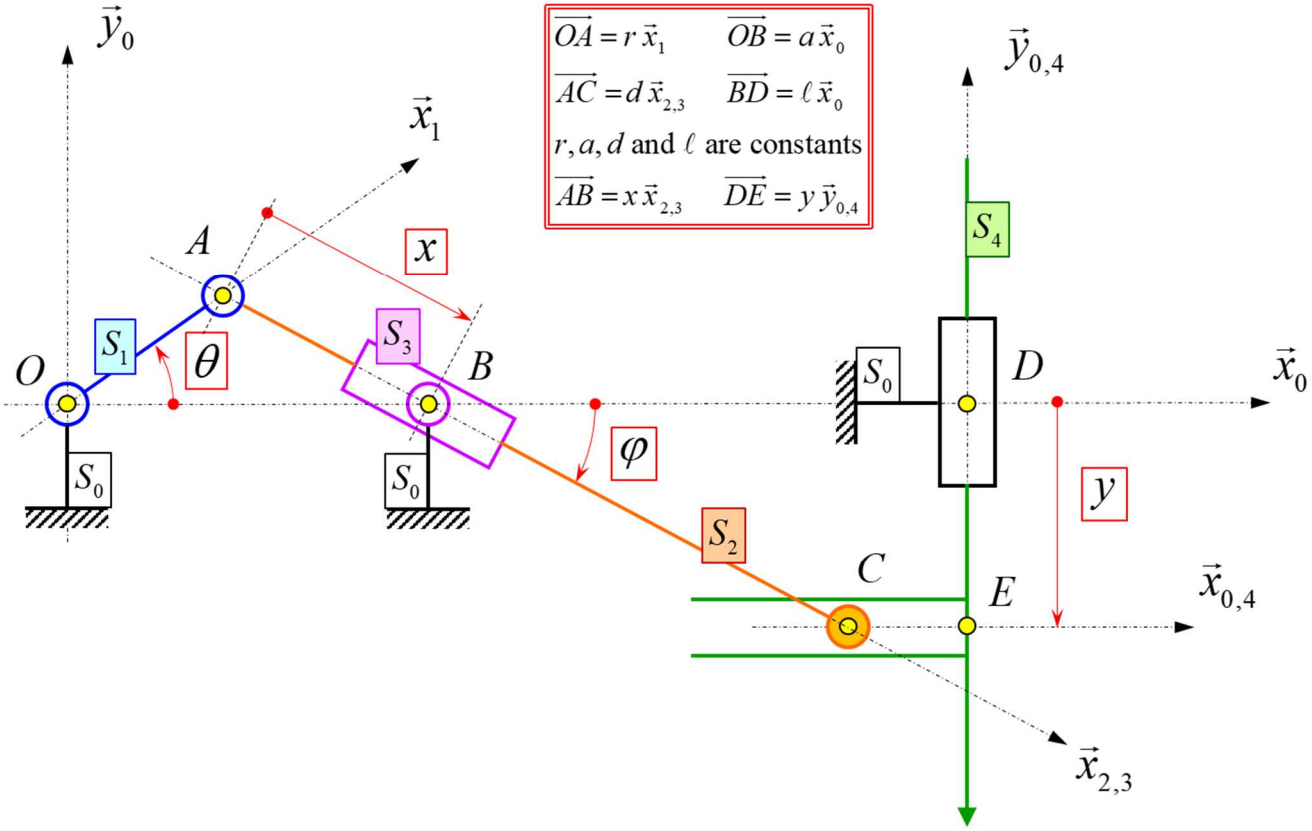
INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Monday 14th December 2020

Kinematics

Please copy the following sentence**: '***I hereby certify that I will not cheat and have no exchange of information with anybody but the teacher invigilating the test'* and **sign** on your paper

The planar system shown in the figure below is used to operate a needle (S4) via a motion transformer known as Hoeckens mechanism.The principle of operation can be visualized with the animation "Hoeckens_linkage_Animated.gif".



The mechanism comprises :

- A crankshaft S1, connected to the ground S0 by a revolute joint of axis $(O, \vec{z})$.

  Motion parameter for 1/0 : $\theta = (\vec{x}_0, \vec{x}_1)$

- A rod S2, connected to crankshaft S1 by a revolute joint of axis $(A, \vec{z})$

  Motion parameter for 2/0 : $\varphi = (\vec{x}_0, \vec{x}_2)$

- A rocker S3, connected to rod S2 by a prismatic joint of axis $(B, \vec{x}_{2,3})$

  Motion parameter for 3/2 : $x = \overrightarrow{AB} . \vec{x}_{2,3}$

- Needle S4, connected to the ground S0 by a prismatic joint of axis $(D, \vec{y}_{0,4})$

  Motion parameter for 4/0 : $y = \overrightarrow{DC} . \vec{y}_0$

Moreover :

- Rocker S3 is connected to the ground S0 by a revolute joint of axis $(B, \vec{z})$ **with no parameter.**
- Needle S4 is connected to rod S2 by a linear annular joint of axis $(E, \vec{x}_{0,4})$ **with no parameter**.

Questions :

Q1 Graph of links and change of basis diagrams. (/2)

Q2 Develop the constraint equation(s) associated with the closure at point B. /3)

Q3 Deduce the expressions of x and φ in terms of θ and the geometrical parameters a and r. (/2)

Q4 Calculate the velocity and acceleration of point A with respect to the ground S0. (/2.5)

Q4 Specify the nature of the motion 3/2 and give the sum and moment about B of its kinematic screw (wrench) in terms of θ, $\dot{\theta}$, a and r. (/3)

Q5 Express the coordinates of $\vec{BC}$ in terms of d and x. Deduce the velocity vector of point C with respect to the ground S0 in terms of $d, x, \dot{x}$ and $\dot{\varphi}$ (/2.5)

Q6 Give the condition imposed by the closure at point C**.** Deduce the expression of y in terms of d, x and φ (/3)

Q7 Determine the degree of mobility of the mechanism. (/1)

Important:

Please note that:

a) 1 mark will be attributed to the quality of written expression, the respect of appropriate symbols and methodologies

b) The absence of the 'no-cheating' statement and signature will be understood as a refusal to comply with the no-cheating policy and a mark of 0/20 will therefore be systematically assigned to this test.