MAS414 lecture 5 exercises

Exercise 05-01

Set up the kinematic constraint equations for the mechanical system shown in figure 1. Only the crank shaft (body ①) and the slider (body ②) are to be seen as bodies. Body ③ is not a mechanical body in this exercise. Write the equations by hand and implement them in Matlab to carry out a forward dynamics analysis for the time $t = 0\,\mathrm{s}..20\,\mathrm{s}$. A constant moment $M_{act} = 35\,\mathrm{Nm}$ is applied to body ① as illustrated in figure 1. Viscous friction applies between body ② and ground with a friction coefficient $c = 25\,\frac{\mathrm{Ns}}{\mathrm{m}}$. Gravity applies in the negative y-direction. The following mass properties are known: $m_1 = 7\,\mathrm{kg}$, $J_{G1} = 1.4\,\mathrm{kgm}^2$, $m_2 = 15\,\mathrm{kg}$ and $J_{G2} = 2.7\,\mathrm{kgm}^2$. In the initial position the bodies are at rest with $\phi_1 = \phi_2 = 0\,\mathrm{rad}$. Plot the results for position, velocity, acceleration, and reactions.

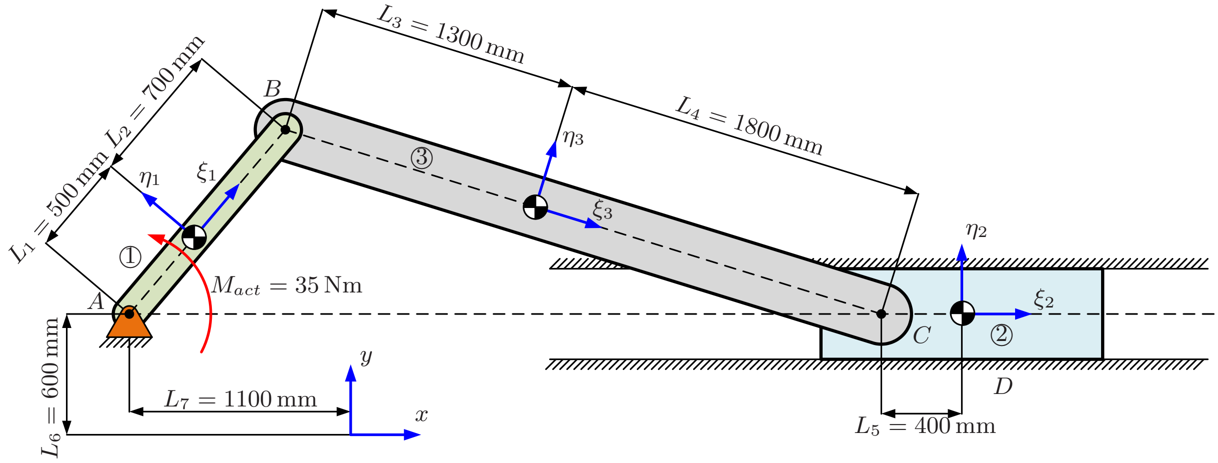


Figure 1: Slider crank system..

Exercise 05-02

Set up the kinematic constraint equations for the mechanical system shown in figure 2. In this exercise body ③ is to be considered a mechanical body. Write the equations by hand and implement them in Matlab to carry out a forward dynamics analysis for the time $t = 0\,\mathrm{s}..20\,\mathrm{s}$. A constant moment $M_{act} = 95\,\mathrm{Nm}$ is applied to body ① as illustrated in figure 2. Viscous friction applies between body ② and ground with a friction coefficient $c = 10\,\frac{\mathrm{Ns}}{\mathrm{m}}$. Gravity applies in the negative y-direction. The following mass properties are known: $m_1 = 7\,\mathrm{kg}$, $J_{G1} = 1.4\,\mathrm{kgm}^2$, $m_2 = 15\,\mathrm{kg}$, $J_{G2} = 2.7\,\mathrm{kgm}^2$, $m_3 = 10\,\mathrm{kg}$, $J_{G3} = 8.5\,\mathrm{kgm}^2$. In the initial position the bodies are at rest with $\phi_1 = \phi_2 = \phi_3 = \theta$. Plot the results for position, velocity, acceleration, and reactions. Hint: the viscous friction applies along the dashed sliding line - not horizontally.

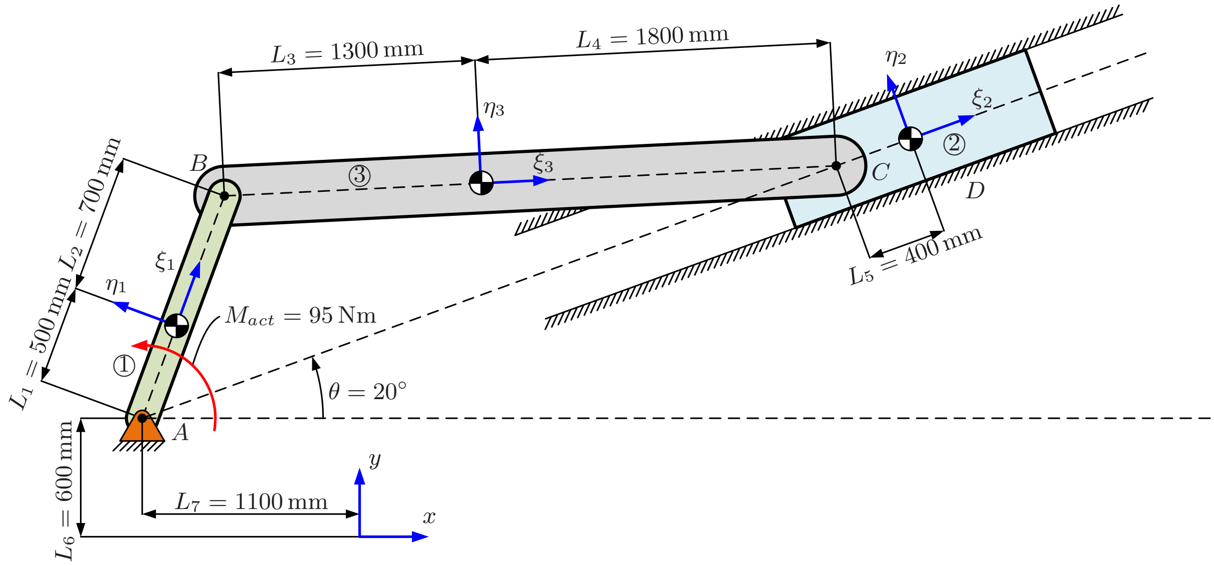


Figure 2: Slider crank system.

Exercise 05-03

Set up the kinematic constraint equations for the mechanical system shown in figure 3. The link between point B and C and the parts in the spring and damper are not considered as mechanical bodies. Write the equations by hand and implement them in Matlab to carry out a forward dynamics analysis for the time $t = 0\,\text{s}..15\,\text{s}$. Gravity applies in the negative y-direction. The following mass properties are known: $m_1 = 3800\,\text{kg}$, $J_{G1} = 3955\,\text{kgm}^2$, $m_2 = 75\,\text{kg}$ and $J_{G2} = 3.1\,\text{kgm}^2$. Plot the results for positions, velocities, accelerations, and reactions. The system starts at rest in the following position (corresponds to $t = 5\,\text{s}$ in Exercise 04-03):

$$\mathbf{q} = \begin{bmatrix} 1.543069001347181\,\text{m} \\ 1.427808830719795\,\text{m} \\ 0.351098023786103\,\text{rad} \\ 1.674584579945459\,\text{m} \\ -0.209133521257303\,\text{m} \\ 0.814184741606332\,\text{rad} \end{bmatrix}$$

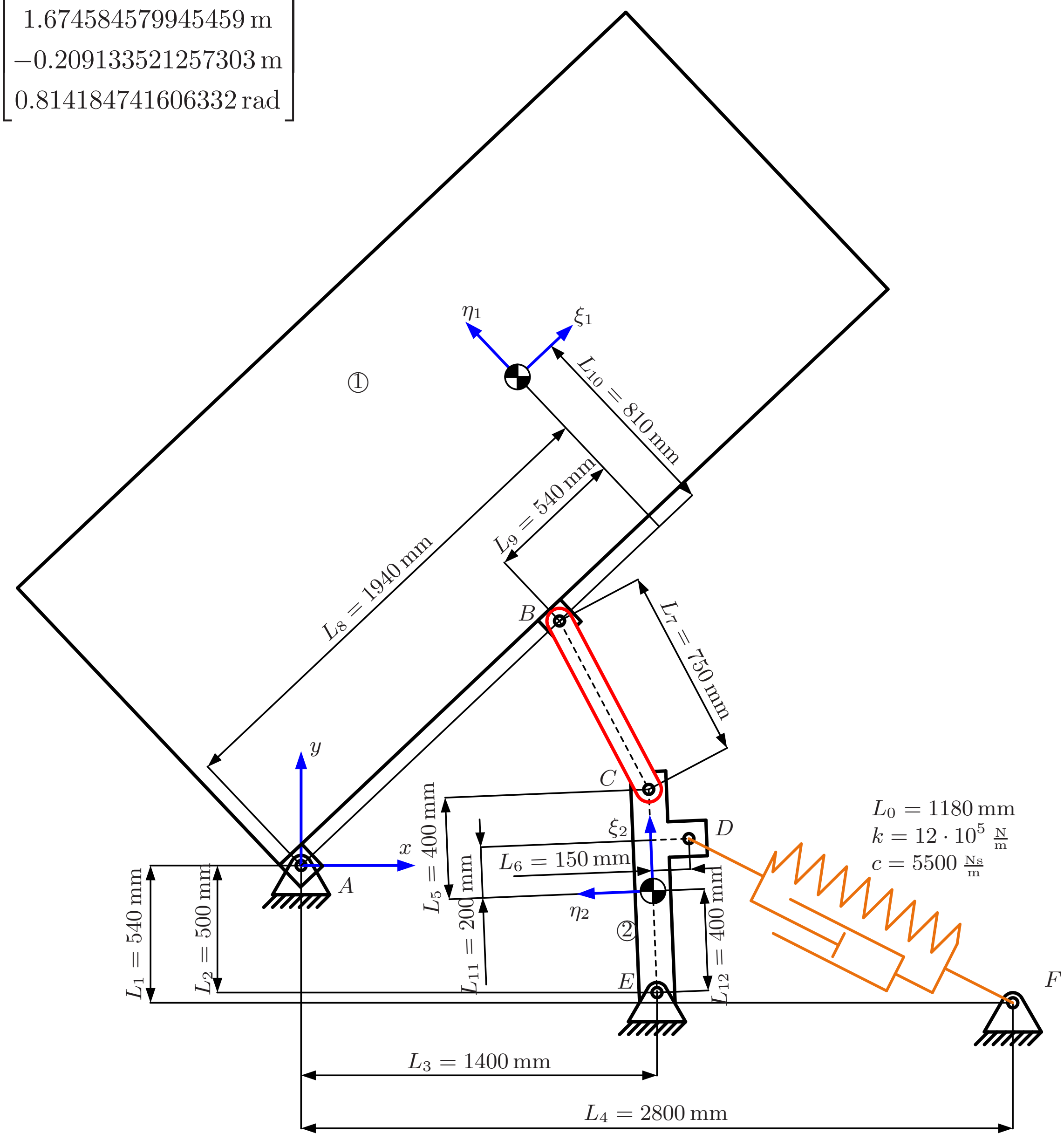
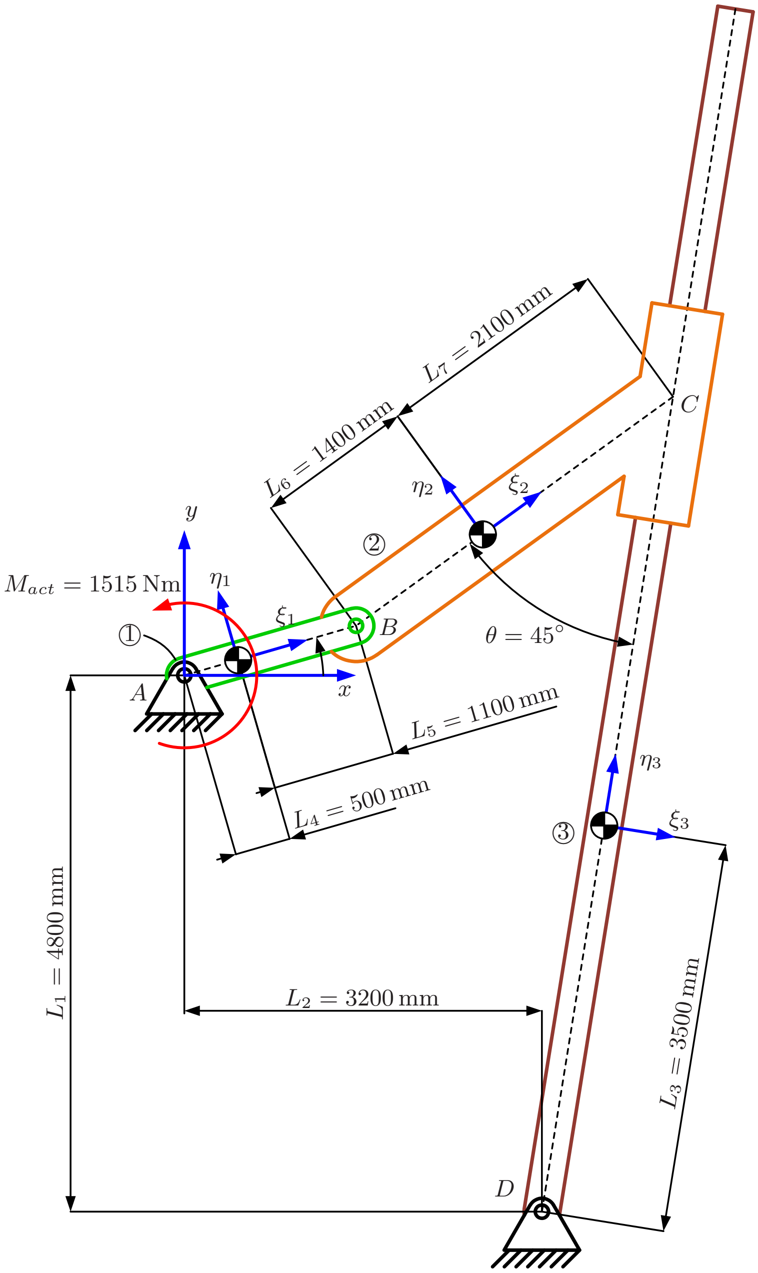


Figure 3: Mechanical system.

Exercise 05-04

Set up the kinematic constraint equations for the mechanical system shown in figure 4. Write the equations by hand and implement them in Matlab to carry out a forward dynamics analysis for the time $t = 0\,\mathrm{s}..20\,\mathrm{s}$. A constant moment $M_{act} = 1515\,\mathrm{Nm}$ is applied to body ① as illustrated in figure 4. Viscous friction applies in the translational joint between body ② and ③ with a friction coefficient $c_{trans} = 145\,\frac{\mathrm{Ns}}{\mathrm{m}}$. In joint B between body ① and ② viscous friction applies with a rotational damping coefficient of $c_{rot} = 120\,\mathrm{Nms}$. Gravity applies in the negative y-direction. The following mass properties are known: $m_1 = 21\,\mathrm{kg}$, $J_{G1} = 5.2\,\mathrm{kgm}^2$, $m_2 = 78\,\mathrm{kg}$, $J_{G2} = 9.2\,\mathrm{kgm}^2$, $m_3 = 124\,\mathrm{kg}$ and $J_{G3} = 526\,\mathrm{kgm}^2$. The system starts at rest with the positions specified in figure 4 (corresponds to $t = 0\,\mathrm{s}$ in Exercise 04-04).



Initial positions:

$$\mathbf{q} = \begin{bmatrix} x_1 \\ y_1 \\ \phi_1 \\ x_2 \\ y_2 \\ \phi_2 \\ x_3 \\ y_3 \\ \phi_3 \end{bmatrix} = \begin{bmatrix} 0.392943630388474\,\mathrm{m} \\ -0.309184901534868\,\mathrm{m} \\ -0.666666666666667\,\mathrm{rad} \\ 2.380517950238401\,\mathrm{m} \\ -0.153538746639594\,\mathrm{m} \\ 0.639803493811704\,\mathrm{rad} \\ 3.707782916206305\,\mathrm{m} \\ -1.337030680175064\,\mathrm{m} \\ -0.145594669588021\,\mathrm{rad} \end{bmatrix}$$

Figure 4: Mechanical system.