PROGRAMMING ASSIGNMENT
MS2111 KINEMATICS AND DYNAMICS OF MACHINERY
Semester 1, 2021/2022

Figure 1 shows a knee prosthetics developed by Biomechanics Laboratory, Faculty of Mechanical and Aerospace Engineering ITB to increase amputees' quality of life. The knee prosthetics use a four-bar mechanism to emulate the motion of a knee, especially its rotation angle, so the amputee could walk as normally as possible. The configuration of the thigh, four-bar mechanism of the knee prosthetic, shank and foot is presented in Figure 2. The kinematics diagram of the knee prosthetics could be simplified by Figure 3. The lengths of links 2, 3, and 4 are L^2, L^3, and L^4, respectively. Link 2 of the mechanism is assumed to rotate with a constant angular velocity ω^2. Please conduct the kinematics analysis of the four-bar mechanism below. You must write down all the matrix needed in the kinematics analysis in A4 papers and write the program in MATLAB or Octave.

Figure 1 Knee prosthetic developed by FMAE ITB

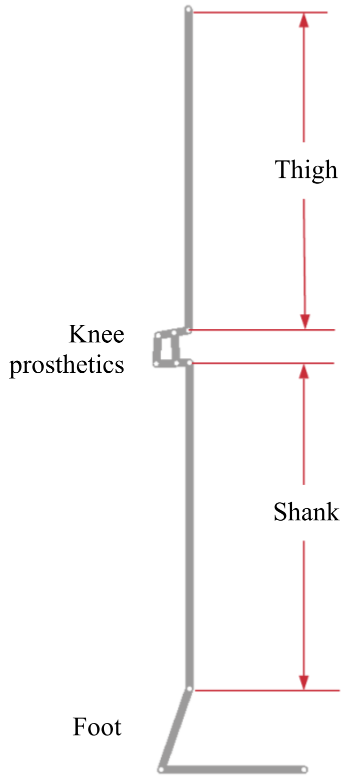

Figure 2 Model of human lower limb

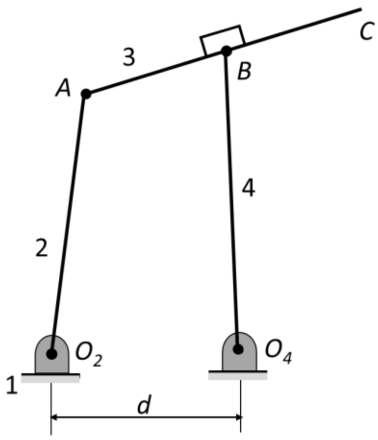

Figure 3 Kinematics diagram of the knee prosthetics

The **input** for the program are the geometry or dimension of the mechanism and the angular velocity of link 2, as follows:

$$d = \begin{cases} 22.5 \text{ cm}, \text{if } XYZ \bmod 3 = 0 \\ 25.0 \text{ cm}, \text{if } XYZ \bmod 3 = 1 \\ 27.5 \text{ cm}, \text{if } XYZ \bmod 3 = 2 \end{cases}$$

$$L^2 = 30 + Z \text{ [cm]}$$

$$L^3 = 36 + X \text{ [cm]}$$

$$AB = BC = \frac{L^3}{2}$$

$$L^4 = 37 + \frac{Y}{2} \text{ [cm]}$$

$$\omega^2 = \begin{cases} 2\ \dfrac{rad}{s} & \text{if } XYZ \text{ is odd number} \\ 4\ \dfrac{rad}{s} & \text{if } XYZ \text{ is even number} \end{cases}$$

where:

L^2	: length of link 2
L^3	: length of link 3
L^4	: length of link 4
d	: distance between O_2 and O_4
ω^2	: angular velocity of link 2
θ_o^2	: initial angle of link 2
XYZ	: last three digits of your NIM, i.e. 13120XYZ

The expected **output** are the plot of:

1. Trajectory of point C in the graph of $r_{A,x}^2$ vs. $r_{A,y}^2$
2. Angular velocity of link 3 vs. time, $(\omega^3 - t)$
3. Angular velocity of link 4 vs. time, $(\omega^4 - t)$
4. Angular acceleration of link 3 vs. time, $(\alpha^3 - t)$
5. Angular acceleration of link 4 vs. time, $(\alpha^4 - t)$

You may determine the initial angle of link 2 (θ_o^2) and simulation time (t) by yourself as long as all the possible movement or configuration of the mechanism are included in the above output.

Submission and due date:

You should submit following documents or files:

1. All the matrices required in the kinematics analysis (e.g. constraint matrix, Jacobian matrix, etc.) in pdf file
2. The meta-file of your program (with extension .m)
3. All the expected plots in .jpg or .png file.

Please submit all the documents or files in .rar or .zip extension to e-learning page (Edunex) or MSTeam channel of your each class before **Wednesday, 13 November 2021**.

Note: please learn how to program in MATLAB or Octave by yourself.