DYNAMICS OF MACHINES

436-354

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ASSIGNMENT 1.

DYNAMIC ANALYSIS OF A ROBOT.

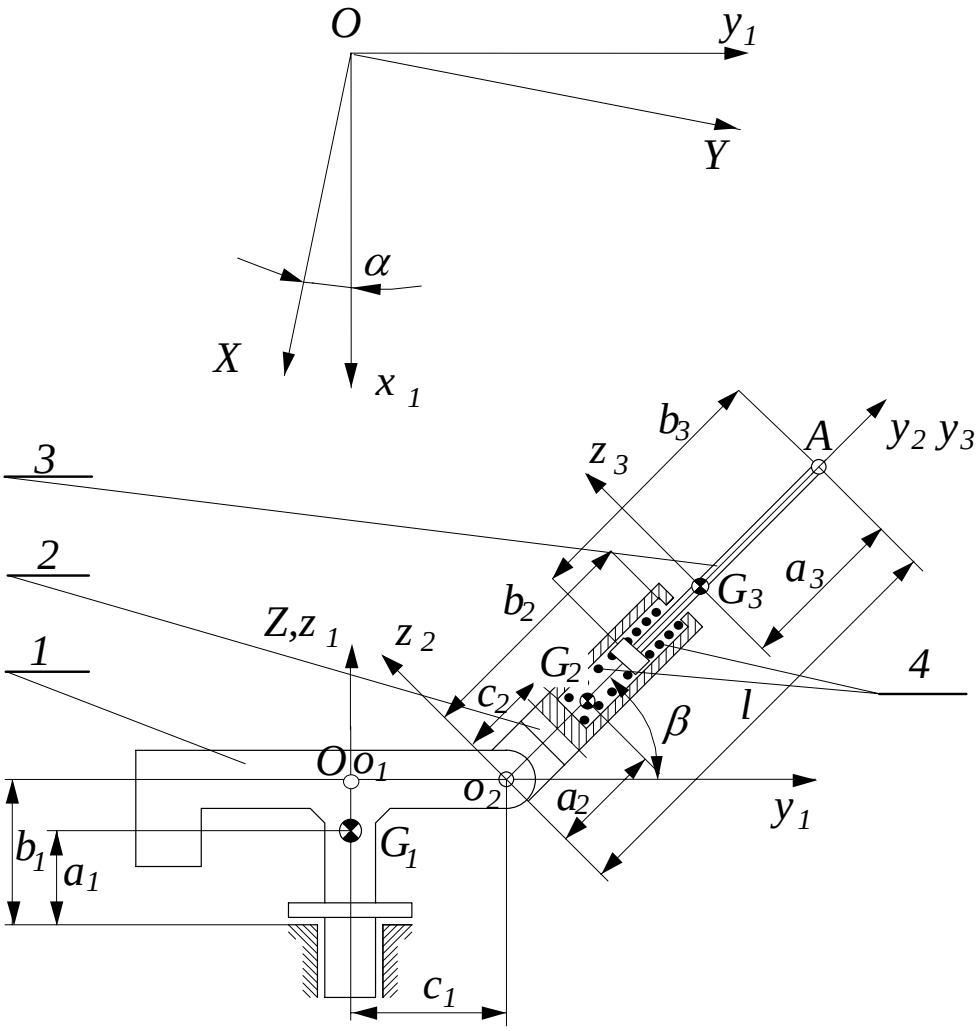

Fig. 1.

Figure 1 shows the physical model of a robot. Its link *1* can rotate about axis *Z* of the inertial system of coordinates *XYZ*. Its instantaneous angular position is determined by the angle α. System of coordinates $x_1y_1z_1$ is fixed to the link *1*. The link *2* is hinged to the link *1* at the point o_2 and can rotate with respect to the link *1* about axis x_2 of the body *2* system of coordinates $x_2y_2z_2$. Its

relative instantaneous angular position is determined by the angle β. The link *3* moves along axis y_2 and its relative instantaneous position is determined by the distance *l*. Two identical springs *4*, each of stiffness *k*, are installed between the cylinder *2* and the piston *3*. Dimensions a_1, a_2 and a_3 determine positions of the centre of gravity G_1, G_2 and G_3 of individual links of the robot.

Motion of the links *1* along coordinate α and link 2 along coordinate β is a known function of time.

$$\alpha = At \quad \beta = B\sin ft$$

For the described system:

1. Derive equations of motion of the system by means of Euler's equations.
2. Derive equations of motion of the system by means of Lagrange's equations.
3. Formulate set of equations which determines reactions in the kinematic constraints and the driving moments along coordinates α and β.

Given are:

m_1, I_{1z1} - mass and moment of inertia of the link 1 about axis z_1

$m_2, I_{2x2}, I_{2y2}, I_{2z2}$ - mass and the principal moments of inertia about axes $x_2 y_2 z_2$ of the link *2*

$m_3, I_{3x3}, I_{3y3}, I_{3z3}$ - mass and the principal moments of inertia about axes $x_3 y_3 z_3$ of the link *3*

k - stiffness of the springs *4*

$a_1, b_1, c_1, a_2, b_2, c_2, a_3, b_3$ - distances defined in Fig. 1

$\alpha(t), \beta(t)$ - motion of the robot along coordinates α and β.

The kinematic analysis, which was the aim of the first assignment, allowed for establishing the following kinematic expressions.

1. absolute angular velocity of the link *2*

$$\boldsymbol{\omega}_2 = \mathbf{i}_2(\dot{\beta}) + \mathbf{j}_2(\dot{\alpha}\sin\beta) + \mathbf{k}_2(\dot{\alpha}\cos\beta)$$

2. absolute angular velocity of the link *3*

$$\boldsymbol{\omega}_3 = \boldsymbol{\omega}_2$$

3. absolute linear velocity of the centre of gravity of the link *2* G_2

$$\mathbf{v}_{G_2} = \mathbf{i}_2(-c_1\dot{\alpha} - a_2\dot{\alpha}cos\beta) + \mathbf{j}_2(0) + \mathbf{k}_2(\dot{\beta}a_2)$$

4. absolute linear velocity of the centre of gravity of the link *3* G_3

$$\mathbf{v}_{G_3} = \mathbf{i}_2(-c_1\dot{\alpha} - (l-a_3)\dot{\alpha}\cos\beta) + \mathbf{j}_2(\dot{l}) + \mathbf{k}_2(\dot{\beta}(l-a_3))$$

Use these expressions to carry out the required dynamic analysis.

Use this page as the first page of your assignment.