

436-353 MECHANICS 2

Unit 2 Mechanics of A Rigid Body

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ASSIGNMENT 1.

KINEMATIC ANALYSIS OF A ROBOT.

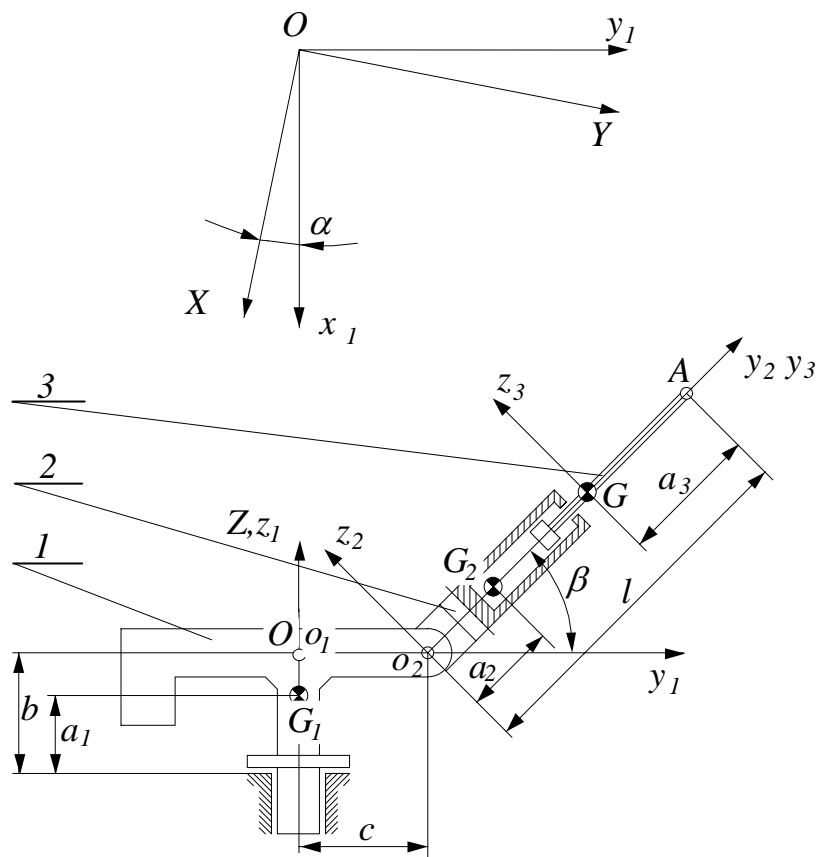


Fig. 1.

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 . The system of coordinates $x_1 y_1 z_1$ 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 the axis x_2 of the body 2 system of coordinates $x_2 y_2 z_2$. Its relative instantaneous angular position is determined by the angle β . The link 3 moves along the axis y_2 and its relative instantaneous position is determined by the distance l . The dimensions a_1 , a_2 and a_3 determine the positions of the centre of gravity G_1 , G_2 and G_3 of the individual links of the robot.

To execute a task, links of the robot have to perform motion determined by the following functions:

$$\alpha(t) = \alpha_1 \left(1 - \cos \frac{\pi}{T} t\right), \quad \beta(t) = \beta_1 \cos \frac{2\pi}{T} t, \quad l(t) = l_0 - l_1 \left(1 - \cos \frac{\pi}{T} t\right)$$

where:

$\alpha_1, \beta_1, l_0, l_1$ - parameters

t - time

T - duration of the task.

For the task described:

1. produce the matrices of the directional cosines between the inertial system of coordinates XYZ and the body systems of coordinates $x_1y_1z_1$ and $x_2y_2z_2$.
2. produce the equation of the trajectory of the point A in the inertial system of coordinates XYZ .
3. produce the expressions for components of the absolute angular velocity for all links along their body systems of coordinates.
4. produce the expressions for components of the absolute angular acceleration for all links along their body system of coordinates.
5. produce the expressions for components of the absolute linear velocity of the centre of gravity of all links along their body systems of coordinates.
6. produce the expressions for components of the absolute linear acceleration of the centre of gravity of all links along their body systems of coordinates.
7. produce the expressions for the kinetic energy for the individual links.
8. compute the magnitudes of the derived expression for $t = \frac{T}{2}$.

Use the following numerical data:

$$b = 0.5m$$

$$c = 0.4m$$

$$a_1 = 0.2m$$

$$a_2 = 0.3m$$

$$a_3 = 0.4m$$

$$l_0 = 1.2m$$

$$l_1 = 0.3m$$

$$\alpha_1 = \pi \text{ rad}$$

$$\beta_1 = 0.25\pi \text{ rad}$$

$$T = 2s$$

$$m_1 = 80kg$$

$$m_2 = 40kg$$

$$m_3 = 20kg$$

$I_{1z_1} = 15kgm^2$ - moment of inertia of the link 1 about axis z_1

$$I_{2x_2} = 5kgm^2$$

$$I_{2y_2} = 3kgm^2$$

$I_{2z_2} = 5kgm^2$ - moments of inertia of the link 2 about

the principal axes $x_2y_2z_2$.

$$I_{3x_3} = 2kgm^2$$

$$I_{3y_3} = 0.5kgm^2$$

$I_{3z_3} = 2kgm^2$ - moments of inertia of the link 3 about

the principal axes $x_3y_3z_3$.

**Use this page as the first page of your assignment.
You can work on this assignment individually or in teams of two.**