A red and white logo

Description automatically generated with low confidence

**HACETTEPE UNIVERSITY**

**MECHANICAL ENGINEERING DEPARTMENT**

**OMU 493 COMPUTATIONAL MULTI-BODY DYNAMICS**

**Term Project**

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# DESIGN AND ASSEMBLY PROCESS

A picture containing antenna, tool, pole

Description automatically generated A picture containing wrench, tool

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A picture containing child art, LEGO

Description automatically generated A picture containing LEGO, toy, screenshot

Description automatically generated

A picture containing swing, playground, toy

Description automatically generated

**SIMULATION**

**Case 1**

Here, we obtained the position change of the effector part.

A picture containing text, screenshot, software, computer icon

Description automatically generated

As a result: we moved the effector part 0.1 m in the z direction. And we track the position change form time 0 to time 1second as we see below:

A picture containing text, diagram, graphics software, software

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A picture containing text, graphics software, diagram, software

Description automatically generated

**Case 2**

Here the task is to move the effector part to the desired location. By using this function, we define the motion of the effector part more smoothly.

Part 1

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In part 1, to calculate the simple result we define a sinusoidal function in the z direction. We move the effector part only in the z direction. And during this motion we keep the x and y axes acceleration 0.

A picture containing screenshot, graphics software, multimedia software, software

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A screenshot of a computer

Description automatically generated

Servo motor 1 angular acceleration:

A graph on a graph

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Servo motor 2 angular acceleration:

A picture containing screenshot, text, plot, line

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Servo motor 3 angular acceleration:

A picture containing screenshot, line, plot, text

Description automatically generated

**Part 2:**

Moving the effector part as 7cm in x direction and 7cm in y direction at the same time. Here Z axis is constant during the motion.

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A white paper with writing on it

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Sinusoidal function is used as we learned in the lecture notes:

A screenshot of a computer

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A picture containing swing, playground

Description automatically generated A picture containing playground, swing

Description automatically generated

Before the motion:

A picture containing screenshot, diagram, tool

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After the motion:

A picture containing screenshot, text, tool, diagram

Description automatically generated

Servo motor 1 angular acceleration:

A picture containing line, plot, text, screenshot

Description automatically generated

Servo motor 2 angular acceleration:

A picture containing text, line, plot, screenshot

Description automatically generated

Servo motor 3 angular acceleration:

A picture containing text, plot, line, screenshot

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**Case 3**

Forward kinematics using the angular acceleration data from case 2 is used here.

At the time of 0 second:

A picture containing screenshot, text, graphics software, software

Description automatically generated

At the time of 1 second: Here position is changed as we expected.

A picture containing text, graphics software, software, screenshot

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Servo motor 1:

A screen shot of a graph

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Servo motor 2:

A screen shot of a graph

Description automatically generated with medium confidence

Servo motor 3:

A screenshot of a computer

Description automatically generated with medium confidence

**Torque Calculation**

Servo motor 1:

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Servo motor 2:

A picture containing text, plot, line, screenshot

Description automatically generated

Servo motor 3:

A screen shot of a graph

Description automatically generated with medium confidence

**Constraint Force Calculation**

Servo motor 1:

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Servo motor 2:

A screen shot of a graph

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Servo motor 3:

A screen shot of a graph

Description automatically generated with medium confidence

# ERRORS

In the designing process of the system during the assembly process, many errors occurred from Visual Nastran.

A close-up of a mechanical arm

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In this figure of error is a constraint connection between different parts. Adding axes and correct degrees of freedom fixed this error.

A picture containing screenshot, text, graphics software, multimedia software

Description automatically generated

Another error, we got inconsistent constraints warning by assigning restraints to the system. We solved this problem by fixing base parts in position properties.

A picture containing screenshot, text

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In this figure, the end-effector motion equations that we defined with prescribed motion were at zero when the velocity of the end effector was not zero. To correct this situation, we canceled the prescribed motion and the positions and velocities of its parts reached 0 after simulation.

A computer screen shot of a machine

Description automatically generated with low confidence

Due to the Inconsistent Constraints warnings, we received in the last figure, we thought of using the inverse kinematic equation to give system acceleration.