Kinematics and Dynamics of Mechatronic Systems

General guidelines for the project:

The project consists in solving tasks from the field of kinematics and dynamics for a robotic manipulator structure designed to move an object with imposed dimensions from one place to another in a defined workspace, using the assigned end-effector (gripper) schematic. The way of gripping the object is arbitrary, as is its shape, as long as it can be described with at most three parameters (e.g. width, length, height). It can be, for example, a cylinder, cuboid, etc. The dimensions will be imposed by the class instructor. The material of the item does not matter, as the transported item will not be included in the dynamics calculations. The type of gripper jaws should correspond to the object to be grabbed.

As for the manipulator, it has to be capable of moving the given object in space, so it should be able to perform movement *in all three axes*. The manipulator configuration is *arbitrary*—provided that *it is not Cartesian*. The dimensions of the manipulator and the gripper should be selected proportionally to the given dimensions of the object, arbitrarily assuming that *the minimum length* of each link is *at least three times* greater than the largest dimension of the transported object. For dynamics calculations, determine the material of the links and their masses. A cross-section should be assumed in which the smaller dimension is *at least one-tenth* of the length of *the longest* link. It is necessary to assume the uniformity of the link material and the same cross-section over the entire length. For the calculations of dynamics, for simplicity, it can be assumed that the links are slender rods; however, the previously calculated mass values must still be used.

A 3.0 pass:

A schematic of the structure of the manipulator should be presented and its dimensions should be determined (based on the dimensions of the object). The schematic does not have to be "three-dimensional," but it should be readable. The project must include a solution to the simple kinematics problem using the Denavit–Hartenberg notation for the given dimensions. You must also specify the value ranges of the joint variables and the dimensions of the workspace. Multiply the individual transformation matrices by each other to obtain a matrix expressing the transition from the base system to the final one. Then, solve the inverse kinematics problem and choose a trajectory within the workspace along which the manipulator is to move the object. Make a plot of the chosen trajectory and plots showing the values of the joint variables. The solution for this grade does not need to include the gripper or its orientation.

A 4.0 pass:

Meet the requirements for a 3.0 with the following modifications: Assume the dimensions of the gripper based on the given dimensions of the object and present it in a schematic drawing. Include the gripper in your calculations, as well as its orientation with respect to the object being grabbed. In addition, determine the number of DOFs and its displacement characteristics. Plot it.

A 5.0 pass:

Meet the requirements for a 4.0 and furthermore: Solve the inverse dynamics problem, using e.g. Lagrange's equations, to determine the torques (and forces) required for the individual joints to move the manipulator from point A to point B in order to transport the object for the given trajectory. For the sake of simplicity, we exclude the end-effector (gripper) and the mass of the transported object from the calculations. Plot the trajectory and provide plots of the torques (and forces) for the individual links.

It is also possible to get a grade "in between," if the solution is halfway between two grades. For a 4.0, you can also do the part for a 5.0 pass and skip the part for a 4.0 pass.

Any code used in the project should be included as a listing at the end.

Send in the project as a PDF with a name such as *KADOMS_2025_Project_LastnameFirstname123456.pdf*, where *123456* is your student ID, before our last class (2–3 days). Give your message a title of the form *KADOMS 2025 Project Lastname Firstname 123456* and send it to ddamian@agh.edu.pl. When working in a pair, add *_LastnameFirstname123456* in the PDF's filename before the extension and *Firstname Lastname 123456* in the title of the message, respectively.