FR- Home task (Differential kinematics)

Task:

1) Derive the jacobian matrix for your robot model.
2) Implement a function for your robot model from the previous assignment. (you can write it within your robot class)
3) Use the Jacobian matrix to analyze **Elbow** singularities.
4) Use the Jacobian matrix to analyze **Wrist** singularities.
5) Jacobian usage:
    a) Give a vector of joint velocities $[\dot{Q}]$ then, calculate the velocity of the end effector and numerically integrate the system over multiple time steps.

$$\dot{x} = J(q)\,\dot{q}$$

    b) Plot joint and end effector's positions over the calculated period
    c) Repeat the process with a different step size
    d) Reflect on the results. (what can you notice regarding the end effector's motion?)
6) Inverse Jacobian:
    a) Give a vector of cartesian velocities $[\dot{X}]$ then, use the inverse jacobian matrix to calculate the joint velocities and integrate it over multiple time steps.
    b) Plot joint and end effector's positions and velocities.
    c) Repeat the process with a different step size.
    d) Reflect on the results. (what can you notice regarding the end effector's motion?)
7) Assume your robot is at a singular configuration (wrist singularity or arm singularity) which means the jacobian matrix cannot be inverted at the current configuration. Find all possible solutions that allows you to resolve this singularity and regain full matrix rank. (**hint**: analyze the null,column and row space solutions of the jacobian matrix)

References:

It is recommended to refer to these references for information about implementation of Jacobian and singularity analysis.

1) B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, "Robotics: Modelling, Planning and Control", 3rd Edition, Springer, 2009

2) Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Dynamics and Control, Second Edition, John Wiley & Sons, Inc. 2008

Submission:

You need to submit code and report:
In your report:

- A scheme of your robot model.
- Derivation of all your solutions. (mathematical formulations)

In your code:

- All solutions implemented.
- It is advisable to reuse the code from previous assignments.

Bonus task: (+2 points)

A) Implement animation of the robot's motion.
B) Derive the Jacobian matrix numerically (you need further reading about deriving orientation)
C) Validate the solution of numerical approach with the solution you implemented in the main task (both should have the same answer)