Introduction to Robotics

Homework 1
Due Date: Sunday, 2 November 2025

1) i) Write down the state space equations (differential equations) for the following robots. For each robot identify the state, control, and control variables. For a given robot, what do the state, control and constant variables represent? Please explain.

a) Unicycle model
b) Differential drive robot
c) Simplified car model
d) Planar Quadrotor

ii) Describe the differences in dynamics between the robot models a, b and c.

2) Simulate the differential equations for the unicycle robot model using Euler's method for time t $\in$ [0, 10] and time step Δt = 0.1. Use the following control input:

$$v = 1 \quad 0 \le t \le 10$$

$$\omega = \begin{cases} 3 & 0.5 \le t \le 1.5 \\ -3 & 2 \le t \le 3 \\ 3 & 4 \le t \le 5 \\ -3 & 6 \le t \le 7 \\ 3 & 8 \le t \le 9 \\ 0 & all\ other\ t \end{cases}$$

With initial conditions x(0) = 1, y(0) = -1, θ(0) = 1.

a) Plot x vs y, x vs t, y vs t and θ vs t. Submit your code and plots.
b) If you plot x vs y at each time step, you'll be able to see a movie of the robot moving in 2D space.

Feel free to simulate different initial conditions and control input sequences to gain a greater understanding.

3) Simulate the state space equations for the differential drive robot model using Euler's method for time t $\in$ [0, 10] and time step Δt = 0.1. Use the following control input:

$$\omega_l = \begin{cases} 20 & 2 \le t \le 3 \\ 20 & 6 \le t \le 7.5 \\ 5 & all\ other\ t \end{cases} \quad \omega_r = \begin{cases} 20 & 4 \le t \le 5 \\ 20 & 8.5 \le t \le 9 \\ 5 & all\ other\ t \end{cases}$$

With r = 0.1, L = 0.9 and initial conditions x(0) = 1, y(0) = 1, θ(0) = 1.

a) Plot x vs y, x vs t, y vs t and θ vs t. Submit your code and plots.
b) If you plot x vs y at each time step, you'll be able to see a movie of the robot moving in 2D space.

Feel free to simulate different initial conditions and control input sequences to gain a greater understanding.