# Homework 3

In this assignment, you will put in practice the concepts of the PID controller. You don't need to write any code for this, just pen and paper can be enough.

While there can be other previous classes that are useful, the main material covered with this assignment is from 10-Control.pdf.

## Assumptions

Assume that you have the Turtlebot robot with a 360 degree field of view LIDAR (the measurement is stored in the ROS message LaserScan), modeled it as a differential drive robot. Assume that the robot can be controlled via a ROS Twist message -- the linear velocity is set to a constant 0.5 m/s, while you can control the angular velocity.

## General Instructions and Submission

**Answer to the following questions**, showing all the relevant drawings and intermediate math work by uploading a PDF file containing the work. You can include code written by yourself if used for doing some of the repeated calculations, but write down the formulas used on paper.

This assignment is **individual** (i.e., no group work, the work should be your own).
You can obtain a total of 5 points for this assignment.

**Q1**:

Consider the wall following problem: the robot must keep following the wall on the right at a given distance (assume that the robot is in an infinitely long corridor, and the robot will not start facing the wall).

Given this problem, submit a document file in PDF format where you should:

1. **write** the model for a general closed-loop controller; in particular, the following elements should be written down explicitly: the state, the actuation command, and the error.
2. **draw** the robot, the wall, and the sensor readings that are useful to understand your model.
3. **specify** how you will use the sensor to measure the state.

**Q2**:

A discrete P controller is used to control the robot with a proportional gain of 1. The robot starting pose is exactly parallel to the wall and the laser sensor returns a measurement of 1.5m to the right of the robot.

Given this discrete P controller, submit a document file in PDF format where you should:

1. **write** how long it will take to get the robot to the target distance of 2m from the wall, using the model you defined in 1, **showing** your calculations and the error over time, at a sampling rate of 0.2 seconds. Note that you can assume that the robot follows the forward kinematics model for the differential drive robot seen in class.

**Q3**:

Considering the scenario in **Q2.**, submit a document file in PDF format where you should:

1. **write** whether the robot is overshooting, **motivating** the answer.
2. if you believe it will overshoot, **write** an option to avoid overshooting and **write** the calculations using that options simulating again the scenario in 2.

**Q4**:

Considering again the scenario in **Q2.**, submit a document file in PDF format where you should:

1. **write** what happens if the sampling rate becomes 0.4 seconds, instead of 0.2 seconds.
2. **write** the calculations and show the error over time.

**Q5**:

Considering the wall following problem above, submit a document file in PDF format where you should:

1. **write** if there is any reason to introduce the integral term. Please motivate your answer.