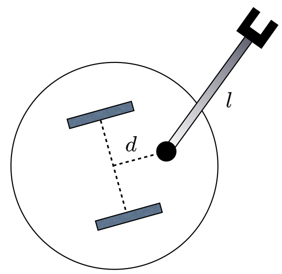
Autonomous and Mobile Robotics
Final Class Test, 2012/2013

Problem 1

Consider the mobile manipulator in figure, consisting of a differential-drive base carrying a 1R planar horizontal arm of length l. The arm is hinged at a distance d from the center of the base, which is located in correspondence of the midpoint of the two wheels.



1. Define a configuration vector for the robot.
2. Write a kinematic model of the robot. [*Hint: a kinematic model for the arm is a simple integrator*]
3. Express the end effector position (x_{ee}, y_{ee}) as an output of the kinematic model. Is it a flat output?
4. Use the kinematic model to design a control law for tracking an assigned trajectory $(x^*_{ee}(t), y^*_{ee}(t))$ with the end-effector. [*Hint: use input-output linearization*]

Problem 2

Consider an RRT-based motion planner for a unicycle robot based on the use of the following motion primitives:

$$v = \bar{v} \qquad \omega = \{-\bar{\omega}, 0, \bar{\omega}\} \qquad t \in [t_k, t_{k+1}]$$

where v and w are, respectively, the driving and steering velocity inputs, $\bar{v}$ and $\bar{\omega}$ are positive constants, and t_k, t_{k+1} are two consecutive sampling instants. The unicycle body is a circle of radius r. Assume that the environment is an empty square room, so that the only obstacles are the room walls. The goal configuration is the center of the room.

1. Which is the minimum necessary clearance (i.e., distance from the unicycle center to the obstacles) for the unicycle at the start to guarantee that the planner will find asymptotically a solution? [*Hint: if the unicycle is facing a wall...*]
2. How would you tune or modify the planner to reduce or possibly eliminate this clearance?

Problem 3

Consider two omnidirectional point robots navigating in an environment containing a single point landmark. Each robot is equipped with a sensor that can measure (1) the relative distance between itself and the other robot (2) the relative distance between itself and the landmark. For simplicity, assume that the sensor can distinguish between the 'other robot' and the landmark, and that it can always 'see' both. Build an EKF-based system for simultaneously localizing the robots and the landmark, given an initial estimate of their positions.

[3 h]