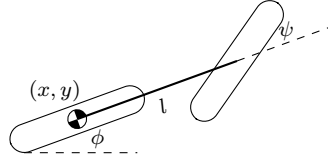


Homework 6: Mobile Robot Kinematics

24-760 Robot Dynamics & Analysis
Fall 2024

Name: _____

Problem 1) Bicycle



You are building a bicycle. To model the system, consider only the horizontal plane kinematics. The wheels are radius $r = 0.3\text{m}$ and spaced $l = 1\text{m}$ apart. Assume the steering turns the front wheel about its center. The state of the system $q = [\psi, x, y, \phi]^T$ consist of the steering angle ψ , the position (x, y) of the rear wheel, and the orientation ϕ of the rear wheel. Consider the bicycle as a kinematic system with input u consisting of forward velocity of the rear wheel v and the rotational velocity of the steering wheel $\dot{\psi}$, so $u = [v, \dot{\psi}]^T$.

1.1) What are the kinematic constraints, $A\dot{q} = 0$, on the velocity of the bicycle states?

1.2) What are the kinematic freedoms, $\dot{q} = H(q)u$, i.e. what are the system velocities written in terms of the control input? (*Note that the wheels reading used G instead of H*).

1.3) Show that your kinematic constraints (represented by A) and kinematic freedoms (represented by H) are consistent with each other.

1.4) What is the turning radius of the bicycle for a given steering angle ψ ? That is, what radius circle will the rear wheel trace out when the front wheel is at an angle of ψ ?