H. Choset Fall, 1999

ME 24-354: General Robotics
1 Exam

Date Handed Out: October 14, 1998
Time Allotted: 1 hour and 15 minutes

- Please show all work.
- You can use one crib sheet.
- You must attempt all *four* problems.
- GOOD LUCK!!!

P1. [***Motion Planning, 30pts***] Determine the shortest path with respect to the $L1$ distance (Manhattan distance function) for the circular robot in Figure 1. Please note that we drew the grid lines to help you out, and they should not be interpreted as pixels, i.e., do not discretize the environment and plan a path with pixels; do this problem in continuous space. See Figure 1.

P2. [***Vision, 30pts***] For parts (a)-(c), refer to Figure 2.

(a) [***5pts***] In a one dimensional environment what does the convolution mask $[1, -1]$ do?

(b) [***5pts***] If this mask were expanded to $[1, 1, 1, -1, -1, -1]$, how would the effect be different?

(c) [***10pts***] If you wished to detect only the indicated edge, how would you post process the output of the convolution of the original signal with the [1, 1, 1, -1, -1, -1] mask? A qualitative sketch of the output of this convolution operation will be helpful.

(d) [***10pt***] Using the thresholding technique from vision, derive a formula for v so that when the threshold filter

$$\begin{aligned} \text{input} \quad &>= v \quad \text{output} \quad = 1 \\ \text{input} \quad &< v \quad \text{output} \quad = 0 \end{aligned}$$

will produce a square wave with the duty cycle of length a (See Figure 3).

P3. [***Non-holonomic constraints/Mobility, 30pt***]

(a) In class, we derived the non-holonomic constraints for the vehicle in Figure 4. Is this vehicle different or the same as the Ackerman Steering, why?

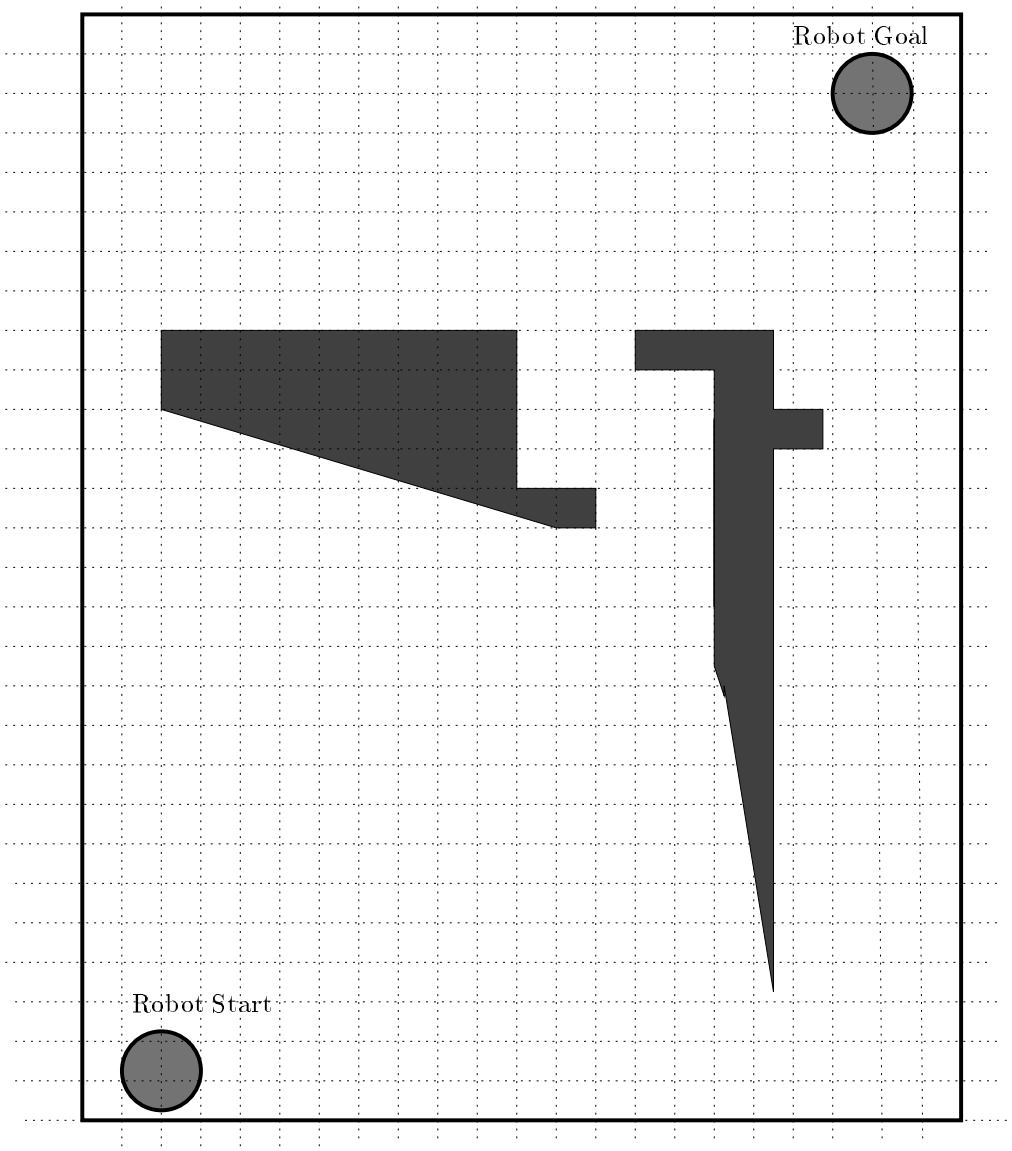

Figure 1. Draw on this page for Question 1.

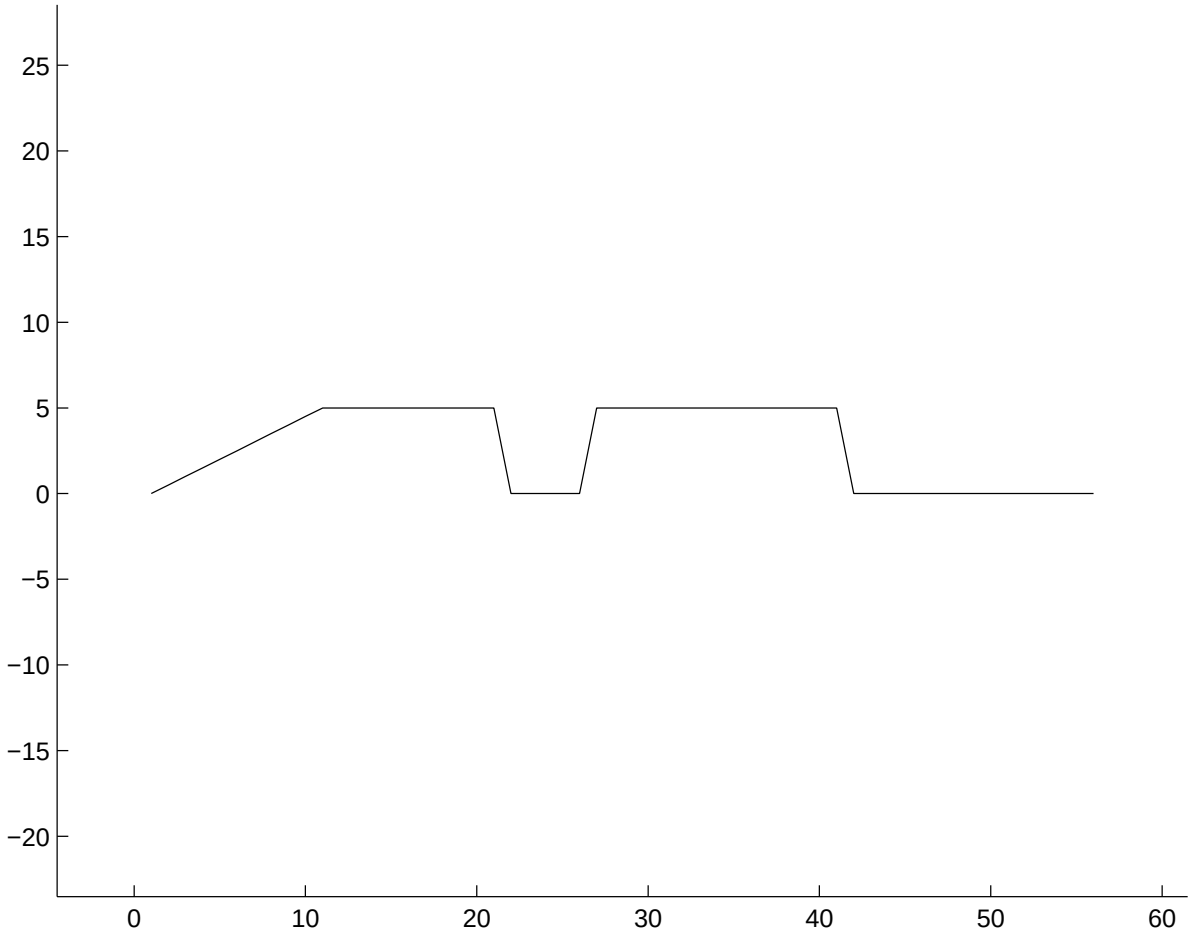

Figure 2.

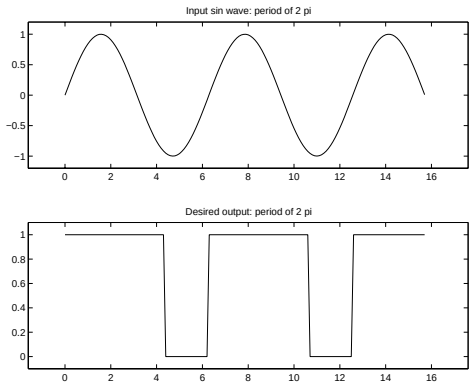

Figure 3.

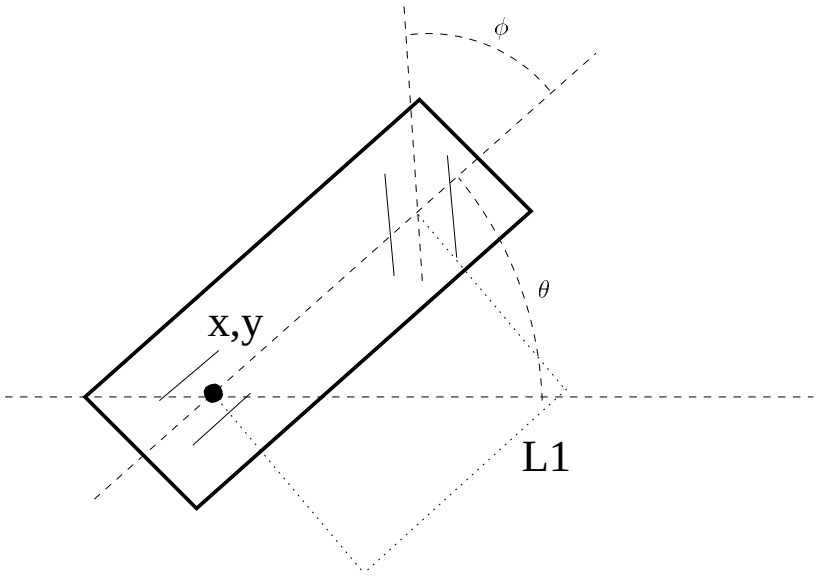

Figure 4. Question 3

(b) The non-holonomic constraints for this car are $w_1(\dot{q})\dot{q} = 0$ and $w_2(\dot{q})\dot{q} = 0$ where

$$w_1(\dot{q}) = [-\sin\theta, \cos\theta, 0, 0]$$

$$w_2(\dot{q}) = [-\sin(\theta+\phi), \cos(\theta+\phi), l\cos\phi, 0]$$

These are constraints on the velocity of the robot. From these constraints, can we determine constraints on the position and orientation of the car, i.e., can these constraints be integrated to determine constraints on the position of the robot?

(c) Is the constraint on position $x^2(t) + y^2(t) = 1$ a non-holonomic constraint. What are the velocity constraints on this system if we want unit magnitude velocity (velocity equal to one).

P4. [***10pts***] Match (connect with lines) the researcher to the research performed.

Ben Brown	Mechanisms and System Integration
Howie Choset	Snake robots
Takeo Kanade	Robot Vision
Illah Nourkhabash	Artificial Intelligence