

16-311: Introduction to Robotics

Spring 2009

1 hour 15 minutes, use one 8.5 x 11" cheat sheet

Name: _____

Team: _____

Score

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

Total: _____

Problem 1 (15 pts):

You are given an input signal $[0 \ 1 \ 3 \ -2 \ 0 \ 1 \ 5 \ 5 \ -1 \ 0 \ 3 \ -2 \ 1 \ 1 \ 0]$.

(a) Convolve the input signal with the mask $\begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix}$ and then convolve the result again with the same mask $\begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix}$. (4 pts)

(b) Convolve the input signal with the mask $\begin{bmatrix} 1 & 1 & 1 \\ 4 & 2 & 4 \end{bmatrix}$. (2 pts)

(c) Is the result the same or different? (1 pt)

(d) Why? (5 pts)

(e) What does convolving with the mask $\begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix}$ do? (3 pts)

Problem 2 (25 pts):

- (a) Draw the generalized Voronoi diagram for the configuration space for the square shaped robot in the orientation shown. (20 pts)
- (b) Draw the shortest path with respect to the L1 metric between the start and goal locations shown. (5 pts)

Figure drawn to scale

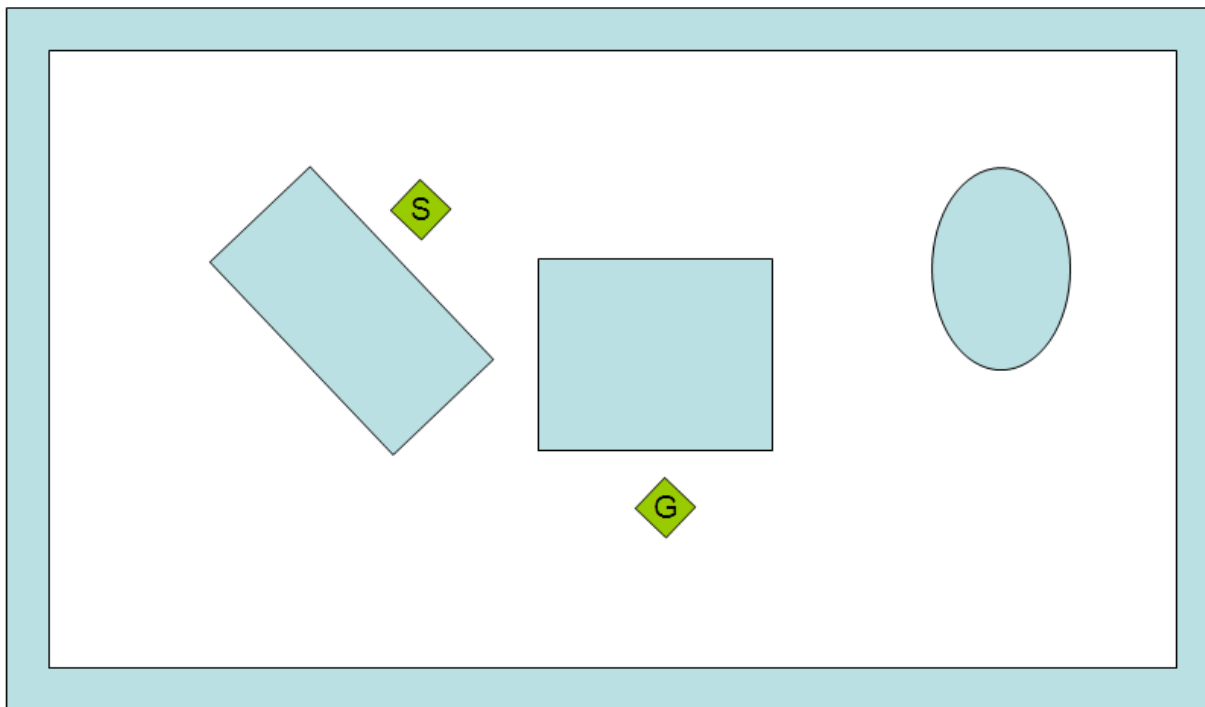
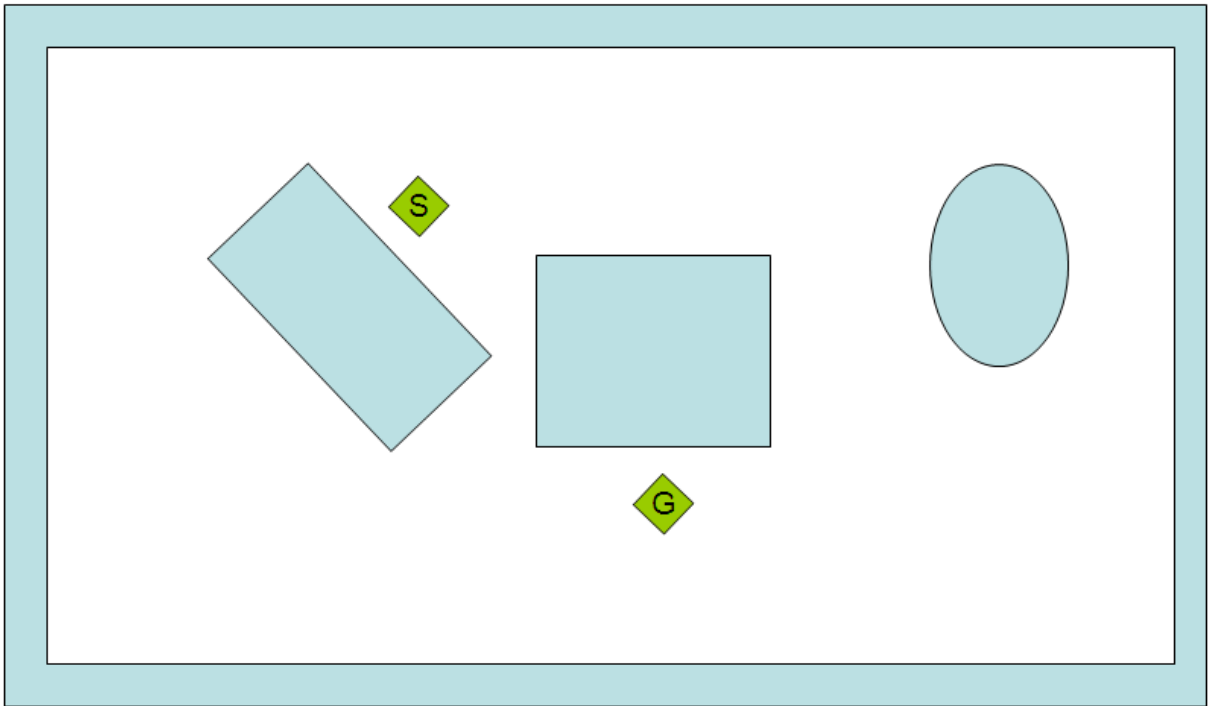


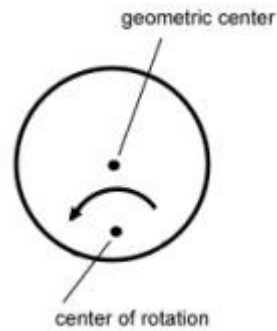
Figure drawn to scale



(Spare if you need it)

Problem 3 (9 pts):

- (a) How many DOF does a circular robot which can translate (along a plane) and rotate on some point other than its center have? (3 pts)



- (b) How many DOF does a robot on a track (i.e. it can only go forwards or backwards), with 2 revolute joints have? Think of it as a train with an arm attached to the top of it. (3 pts)

- (c) What is the dimension of the configuration space of a robot that has an extensible arm with 2 revolute joints? Think of it as a pan/tilt camera that can be lifted/lowered. (3 pts)

Problem 4 (15 pts):

(a) Draw the path using the BUG2 algorithm in the world shown below: (10 pts)



(b) Is this path optimal? (5 pts)

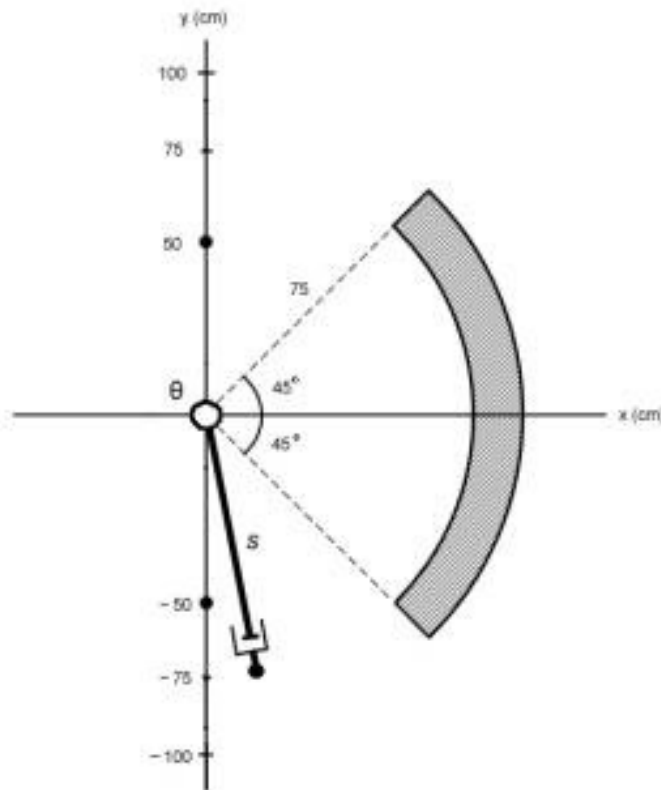
Problem 5 (30 pts):

A 1 DOF prismatic joint is a linear DOF, which as its name suggests, provides motion along a line. Think of it as a telescoping arm. The robot below has a revolute joint with angle θ at the base, which rotates a prismatic joint with length s whose range of motion is 0 to 100 cm. The base joint has no limits. The robot is shown in its initial position.

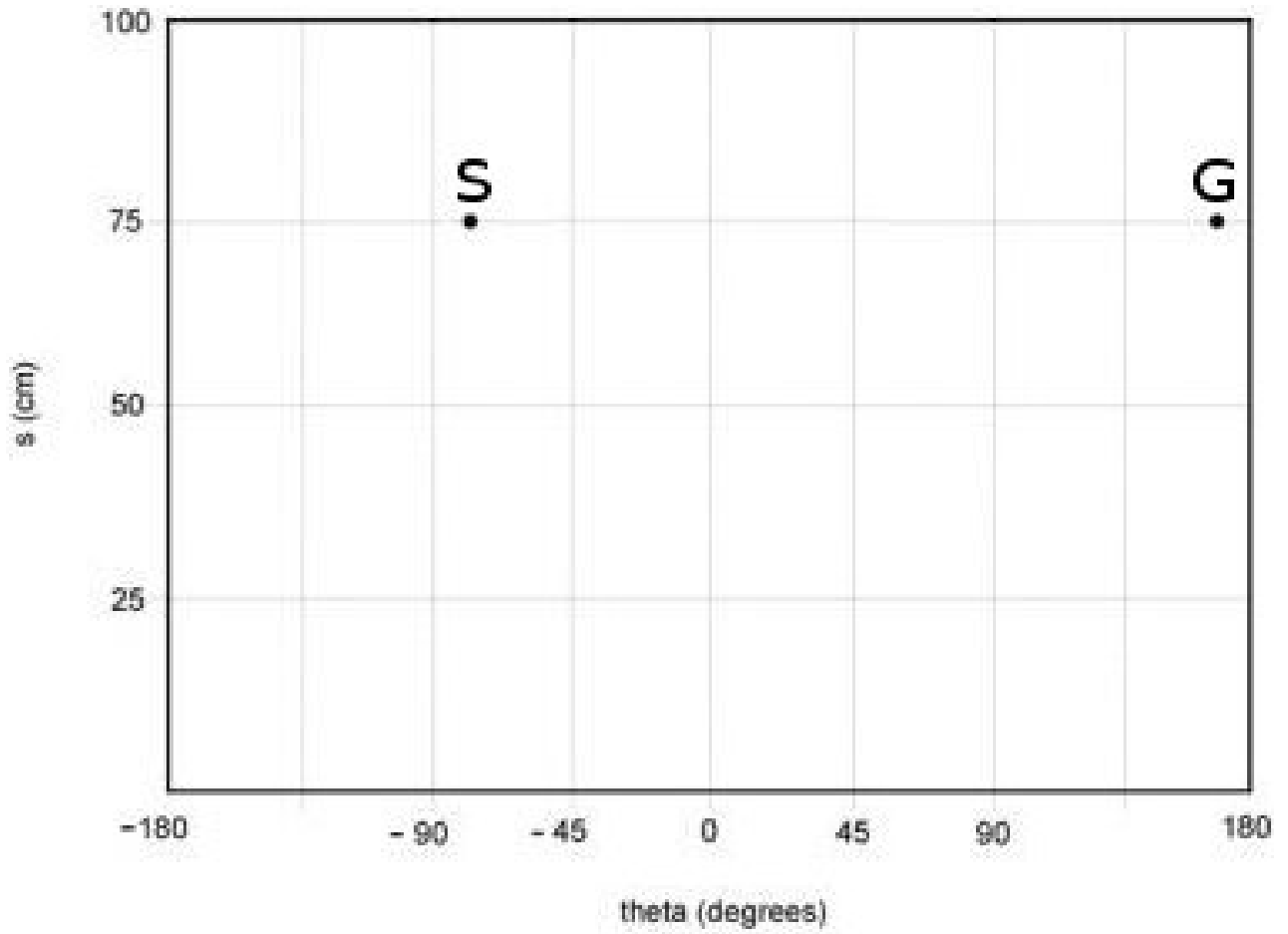
There are 3 obstacles: two point obstacles at $(0, 50)$ and $(0, -50)$, and a curved quarter circular wall with radius 75 cm.

- Draw the the configuration space of this robot on the next page (20 pts)
- Pick a metric and draw the shortest path with respect to that metric. (5 pts)
- Draw the end position in the workspace along with 2 intermediate points on the shortest path. (5 pts)

Workspace:



Configuration space (to be filled in):



Metric used for shortest path: _____

Problem 6 (6 pts):

Answer any 3 of the following 6 questions, clearly crossing out the ones you did not answer.

(a) What is active learning?

(b) Give an example of how active learning can be used in robotics.

(c) What are the benefits of snake robots, as discussed in class?

(d) True or false: we have two eyes so that we can see in stereo. Why?

(e) What is Hans Moravec famous for?

(f) In one or two sentences, describe how back propagation on a neural net works.