H. Choset Fall, 1998

ME 24-354: General Robotics
2 Exam

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

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

P1. [***Sensors,10pts***] A seismometer having a natural frequency of 4 rad/sec and $\zeta = 0.2$ is attached to a structure that performs a harmonic motion. If the difference between the maximum and minimum recorded values is 8mm, find the amplitude of motion of the vibrating structure when its frequency is 40 rad/s.

P2. [***Distance, 10pts***] You are a NY taxi driver in Manhattan and you pick up Matt Mason at the Ritz Plaza 48th Street and 8th Ave. You take him to Time Square at 42nd and 7th Ave. because he claims he wants to see a Disney show. You charge him for 7 units of travel, but he wants to pay you for $6.08 = \sqrt{1^2 + 6^2}$. Why are you *not* cheating him?

P3. [***Motion Planning, 20pts***] Draw the generalized Voronoi diagram of the configuration space of the given environment

P4. [***Inverse Kinematics, 20pts***] A mobile robot has a two link manipulator mounted on top of it. The mobile base can rotate around its vertical axis. Given the position (X_e, Y_e, Z_e) and orientation (Ω_e) of the tip of the manipulator, find the position (x, y) and orientation (α) of the mobile base, and the joint angles of the two-link manipulator.

P5. [***Edge Detection, 20pts***]

Consider the following operations

- Convolve an image with the

$$\begin{bmatrix} -1 & 1 & 0 \\ -1 & 1 & 0 \\ -1 & 1 & 0 \end{bmatrix}$$

- Take the absolute value of the result.
- Rescale the absolute value image so the lowest pixel is 0 and the highest is 255.

- Threshold the resulting image (with an appropriate threshold) where "low" valued pixels become black and "high" valued pixels become white.
- Result is a binary image.

(a) If you chose the appropriate threshold, then what is the meaning of the white pixels?

(b) How do you determine this threshold?

P6. [***Convolution Masks, 20pts***] The Laplacian operator can be used to detect edges in an image.

$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$

Show that the following mask can be used to approximate the Laplacian operator.

$$\nabla^2 \approx \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

Hint: Note that the second derivatives can be written as

$\frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}(\frac{\partial f}{\partial x})$

The approximation of the first derivative centered at $[i, j]$ can be written as,

$\frac{\partial f}{\partial x} = f[i, j+1] - f[i, j]$.

- I hereby promise that the work on this exam is independent work and I acted in good faith in accordance to the University's no-cheating policies.
- I also understand that attendance on the last day of class is mandatory

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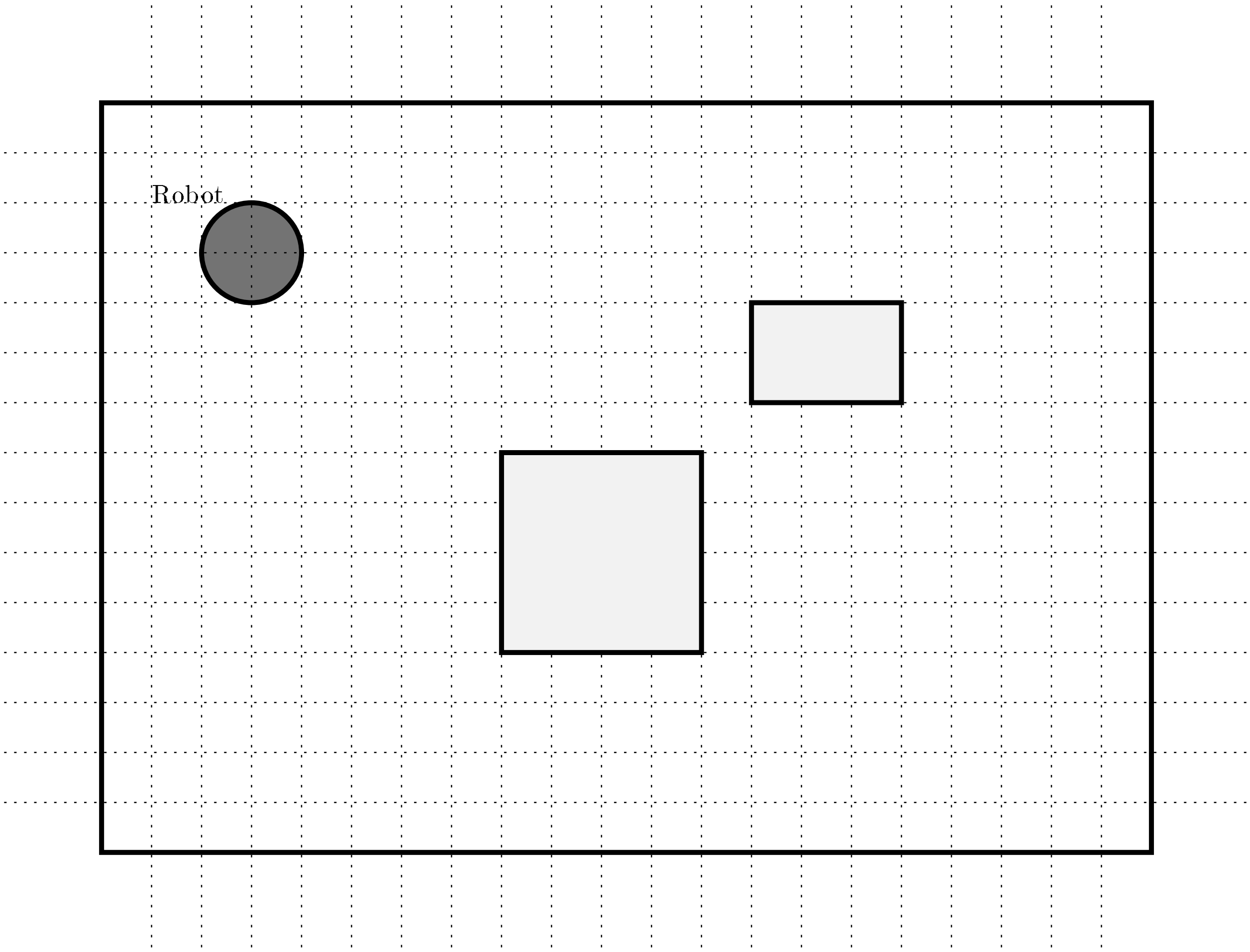
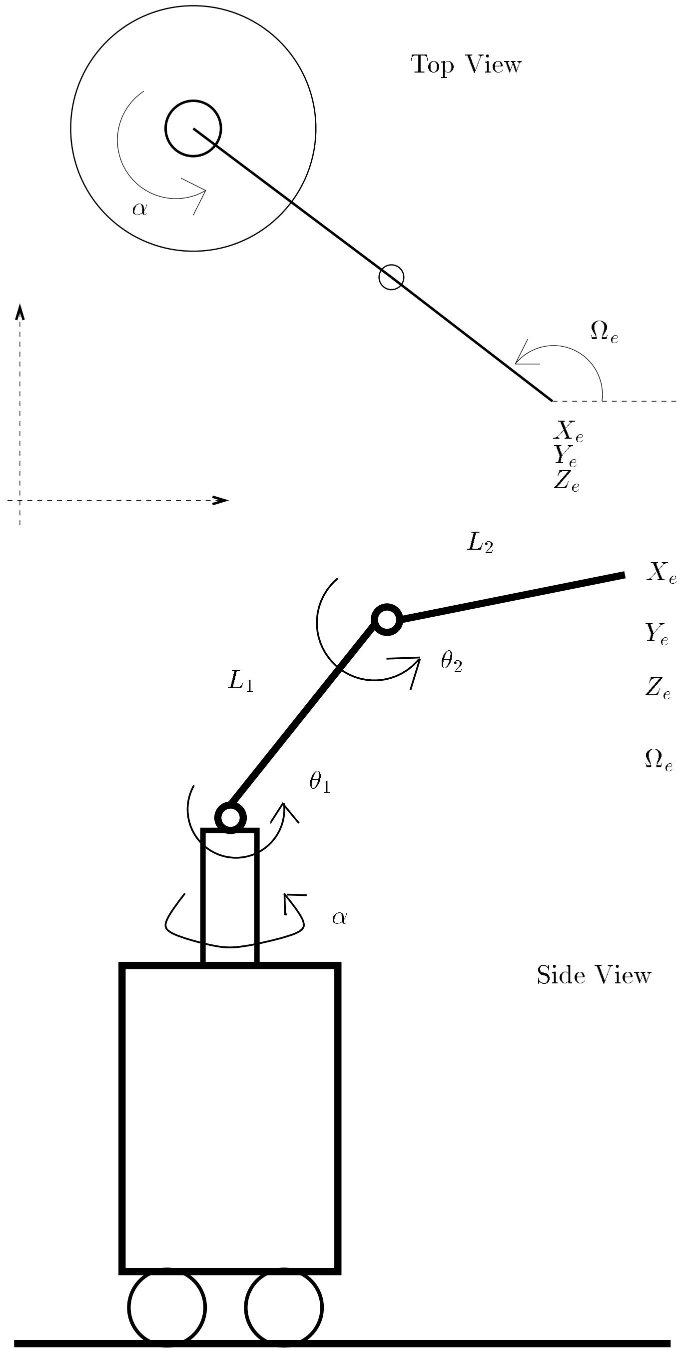
Name


Robot


Top View
α
Ωe
Xe
Ye
Ze
L2
Xe
Ye
Ze
Ωe
L1
θ2
θ1
α
Side View