Name: ____________________________ ITU ID: ______________________ Signature: _____________

BLG456E FINAL

İSTANBUL TECHNICAL UNIVERSITY

Department of Computer Engineering

BLG456E – Robotics – Spring 2013

Final exam.

Duration: 120 minutes

There are <u>10 questions</u>.

Rules:
- <u>Not</u> open-book. No extra notes or papers are allowed.
- Cellphones must be put away. Basic calculators are allowed.
- Answers must be in English.
- **<u>Show your working.</u>**
- Put at least your name or ID on all pages.
- If you write in the margins (you should not need to), indicate under the relevant question.

Question 1 (5 pts): What is an observation model? Give one way that an observation model can be acquired.

A robot is trying to localise in a 4x4 grid, which is surrounded by a wall. It currently has ***no prior information*** *about its current location. It can sense whether it is close to a wall or if there is no wall. Its wall sensor is active with the following probabilities conditional only on whether the current state is next to a wall:*

```
P( WallSensor=on | NextTo(state)=Nothing ) = 0.8    P( WallSensor=on | NextTo(state)=Wall ) = 0.6
P( WallSensor=off| NextTo(state)=Nothing ) = 0.2    P( WallSensor=off| NextTo(state)=Wall ) = 0.4
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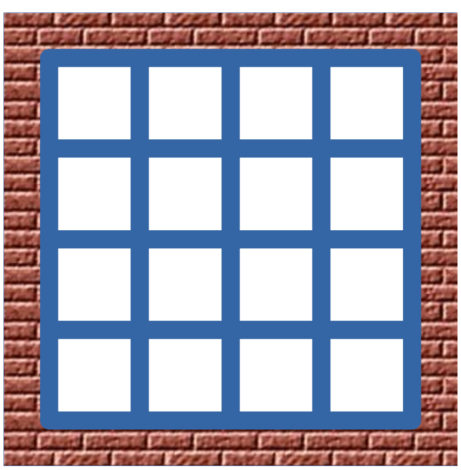
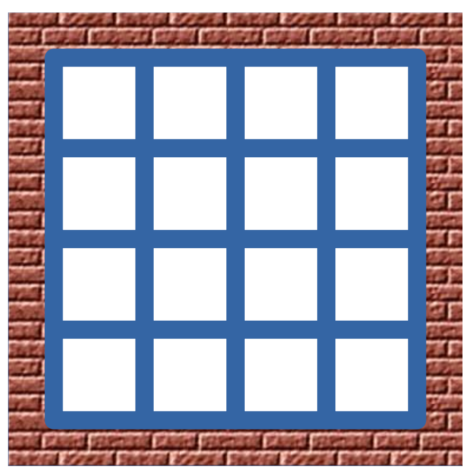
Question 2 (15 pts): Fill in the location *likelihoods* in the grid below left if a wall is detected (`WallSensor=on`). Fill in location *probabilities* in the grid on on the bottom right. You can use fractions instead of decimals if you wish.





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An iterative forward search motion planning algorithm uses the following 3 motion primitives for a car with no reverse gear:

Motion primitive 1:

- Move directly forward at $10ms^{-1}$ for $\frac{1}{10}s$ ($\dot{x}=10ms^{-1}$, $\dot{\theta}=0 rad\ s^{-1}$, $\Delta t=\frac{1}{10}s$)

Motion primitive 2:

- Move arcing left at $10ms^{-1}$ for $\frac{1}{10}s$ ($\dot{x}=10ms^{-1}$, $\dot{\theta}=\frac{\pi}{4} rad\ s^{-1}$, $\Delta t=\frac{1}{10}s$).

Motion primitive 3:

- Move arcing right at $10ms^{-1}$ for $\frac{1}{10}s$ ($\dot{x}=10ms^{-1}$, $\dot{\theta}=-\frac{\pi}{4} rad\ s^{-1}$, $\Delta t=\frac{1}{10}s$).

Question 3 (5 pts): How many possible paths are there after 1 second? (you can write an expression rather than a number).

Question 4 (15 pts): Draw the possible paths that the iterative forward search algorithm would produce after 0.2*s* if the initial pose is $x=0, y=0, \theta=-\frac{\pi}{2}$. Assume that the direction $\theta=0$ is along the positive x axis and that rotations are expressed counter-clockwise (anti-clockwise). Annotate the diagram with *all* the possible robot pose vectors at 0.1*s* and 0.2*s*.

Question 5 (10 pts): Name a different path planning algorithm and compare the iterative forward search algorithm to it in terms of *efficiency* and *completeness*. Give reasoning.

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Question 6 (15 pts): A robot arm is supposed to follow a trajectory. A *P-controller* is installed to control the joints of the arm. Unfortunately, the arm never quite stays on the target and instead wiggles (oscillates) around target. Referring to how a P-controller works:

- Describe what could be going wrong.
- Suggest 2 possible solutions to this problem and their possible drawbacks, if any.

Question 7 (5 pts): In the area of robot audition, what is the "cocktail party effect"?

Question 8 (5 pts): You want a humanoid to learn to balance on one leg. Suggest a data structure and algorithm for learning to do this task.

Question 9 (10 pts): Give two examples each of passive and active sensing. Give one example each of passive and active localisation.

Question 10 (15 pts): A robot is rotated $\pi/2$ radians and then translated (5,-7) where the unit of distance is metres.

1) Give the matrix representing this transform.
2) If the robot's wheel is located at (2,2) (in the original frame of reference) before the transform, what is the position of the robot's wheel after the transform?

Extra space for answers/working

- If you write answers here, indicate as such under the appropriate question.