Name: _____ ITU ID: _____ Signature: _____

İSTANBUL TECHNICAL UNIVERSITY

Department of Computer Engineering

BLG456E – Robotics – Fall 2014

Final exam.

BLG456E FINAL

Duration: 120 minutes

There are 14 questions.

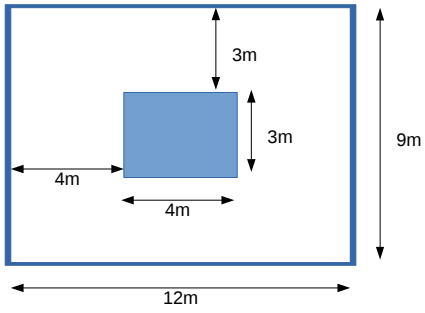
Rules: - Not open-book. No extra notes or papers are allowed.
- Cellphones must be put away. Basic calculators are allowed.
- Answers must be in English.
- **Show your working.** Extra paper can be requested.
- Put your name or ID on all pages.
- If you write in the margins, indicate under the relevant question.

Motion Planning

Question 1 (5 pts): What is meant by a motion planner that is **complete**? Give an example of a complete motion planner.

Question 2 (5 pts): What is meant by a motion planner that is **resolution complete**? Give an example of a resolution complete motion planner.

Question 3 (10 pts): Draw a **visibility graph** for the below map. Underneath the map, draw the graph using the same spatial layout as the map. Label the edges with approximate distances.



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Geometry & Motion

Question 4 (6 pts): A wheel has an **encoder** fitted. The encoder is placed at a radius of 0.2m from the wheel centre and the wheel has a radius of 0.5m. The encoder has 20 divisions detectable by its **breakbeam**. The wheel's encoder records 40 peaks in the breakbeam signal. How far has the wheel travelled?

Question 5 (8 pts): The Turtlebot's left wheel is moving along the ground at a rate of 0.5 metres per second, and its right wheel is moving along the ground at 0.2 metres per second. What are the forward and angular velocities, and the radius of the turning circle of the Turtlebot?

Question 6 (8 pts): Design a set of 3 **motion primitives** for a Turtlebot.

Question 7 (12 pts): Two Turtlebots (A and B) are attempting to coordinate their movements with respect to a map reference frame M.
The position of turtlebot A with respect to the map reference frame is ${}^{M}P^{A} = (5,-5)$. The orientation of turtlebot A with respect to the map reference frame is ${}^{M}\theta^{A} = \pi$.
The position of turtlebot B with respect to the map reference frame is ${}^{M}P^{B} = (10,-5)$. The orientation of turtlebot B with respect to the map is ${}^{M}\theta^{B} = \pi/2$.
Orientations are with respect to the x axis and the x axis of robot reference frames is towards the front of the robot.
1) Give the **transformation matrix** representing the transform from M to A (${}^{M}T^{A}$).

2) Give the **transformation matrix** representing the transform from A to M (${}^{A}T^{M}$).

3) Give the position of Turtlebot B with respect to Turtlebot A (that is, in the Turtlebot A reference frame). For full marks use one of the above transformation matrices in your answer.

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Estimation

Question 8 (5 pts): What is the difference between Maximum Likelihood (ML) Estimation and Maximum A Posteriori (MAP) Estimation? When would ML be better to use than MAP?

Question 9 (10 pts): A robot is attempting to track an object. The object state can be one of: moving left, moving right, or stationary (motionless).
The following probabilistic dynamics model is to be used.

P(MovingLeft|MovingLeft)=0.80	P(MovingLeft|Stationary)=0.10	P(MovingLeft|MovingRight)=0.05
P(Stationary|MovingLeft)=0.15	P(Stationary|Stationary)=0.80	P(Stationary|MovingRight)=0.15
P(MovingRight|MovingLeft)=0.05	P(MovingRight|Stationary)=0.10	P(MovingRight|MovingRight)=0.80

The current estimate of the state at time T is

P(MovingLeft)=0.50	P(Stationary)=0.40	P(MovingRight)=0.1

What is the estimate of the state at time T+1?

Design & Architecture

Question 10 (8 pts): You will develop a robot to assist students in a university library. Give:

- 3 tasks the robot might need to carry out
- 3 important hardware components
- 3 important software capabilities.

Question 11 (5 pts): What kind of robot control **architecture** would you use for this problem and why?

Social Elements

Question 12 (8 pts): What is the most positive outcome of existing robot technology? Why is it the most positive? What is the most negative outcome of existing robot technology? Why is it the most negative?

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Robot Learning

Question 13 (5 pts): In **supervised learning**, a function **f** is learnt such that, for a set of **(x,y)** examples, **y=f(x)** generally holds. How does this function **f** differ from the Q function in **Q-learning/reinforcement learning**?

Question 14 (5 pts): In **supervised learning**, if my system manages to find a **f** such that for a set of **(x,y)** examples, **y=f(x)** holds exactly, it may still not have succeeded in learning **f** well. Why?

Extra space for answers/working

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