



1st SEMESTER EXAMINATIONS 2006

SCHOOL OF ELECTRICAL, ELECTRONIC AND COMPUTER ENGINEERING
INTELLIGENT ROBOTICS ENGT4311

SURNAME: _____ STUDENT NO: _____

GIVEN NAMES: _____ SIGNATURE: _____

This Paper contains 9 pages (including title page)
Time allowed: 2 hours 10 minutes

This is an open book exam. The use of all material is allowed.

Question 1:	10 marks	
Question 2:	15 marks	
Question 3:	15 marks	
Question 4:	10 marks	
Question 5:	10 marks	
Labs:	40 marks	
TOTAL:	100 marks	
All questions are to be answered.		
Answers are to be inserted in the space provided		

PLEASE NOTE

Examination candidates may only bring authorised materials into the examination room. If a supervisor finds, during the examination, that you have unauthorised material, in whatever form, in the vicinity of your desk or on your person, whether in the examination room or the toilets or en route to/from the toilets, the matter will be reported to the head of school and disciplinary action will normally be taken against you. This action may result in your being deprived of any credit for this examination or even, in some cases, for the whole unit. This will apply regardless of whether the material has been used at the time it is found.

Therefore, any candidate who has brought any unauthorised material whatsoever into the examination room should declare it to the supervisor immediately. Candidates who are uncertain whether any material is authorised should ask the supervisor for clarification.

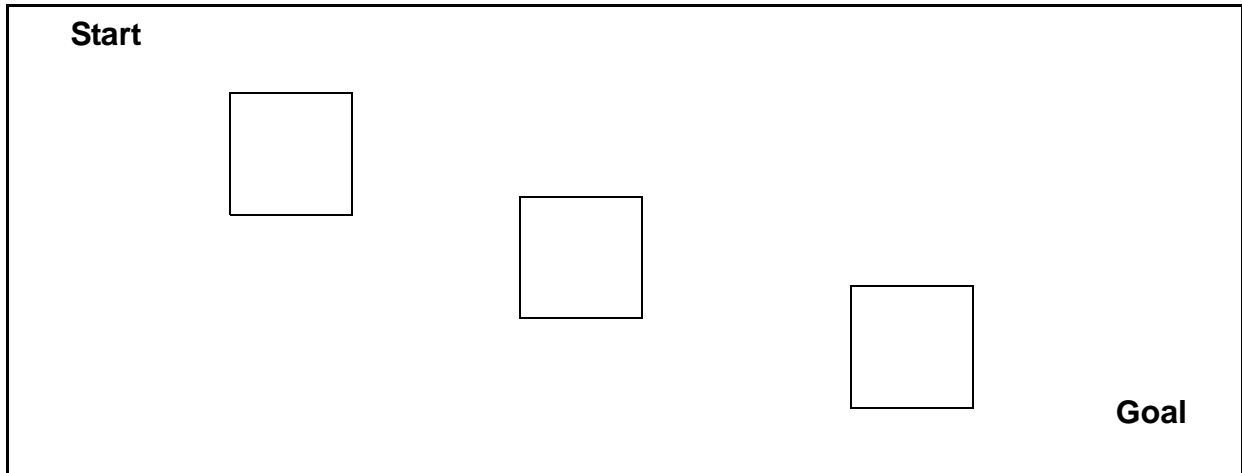


QUESTION 1

Navigation

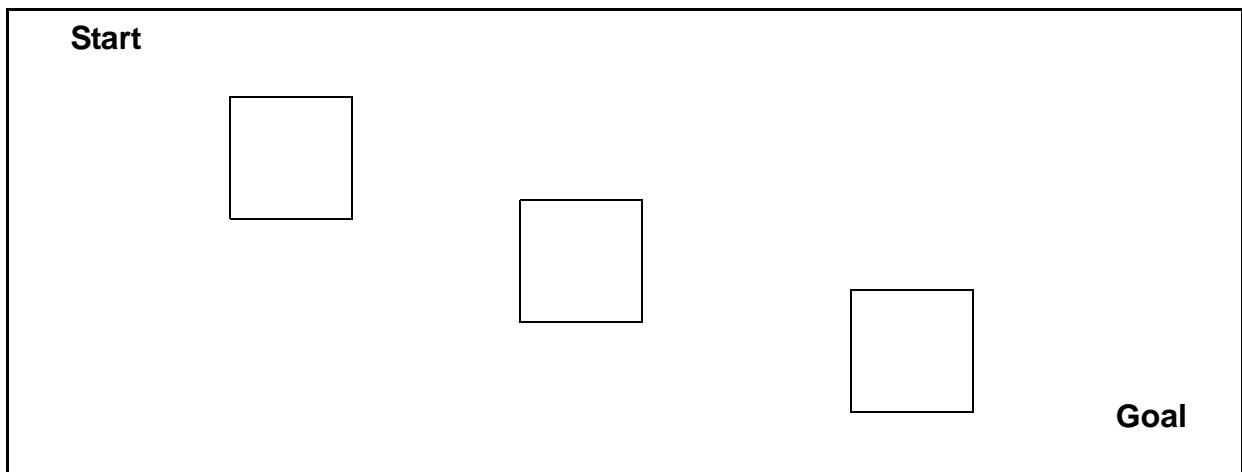
(3+3+4 = 10 points)

(a) Sketch the most likely path from Start to Goal for the Bug1 algorithm:



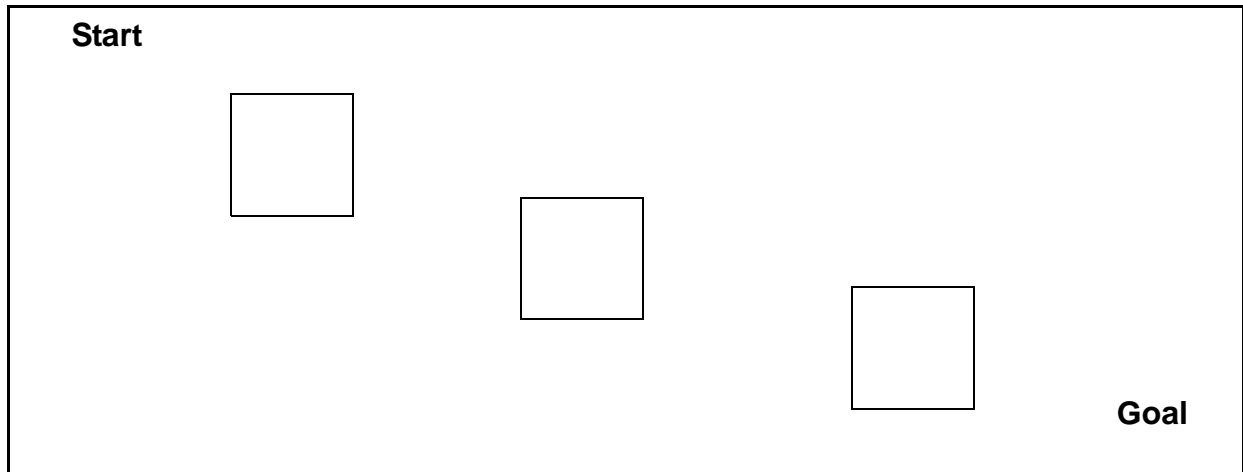
Explanation of algorithm in one sentence:

(b) Sketch the most likely path from Start to Goal for the Bug2 algorithm:



Explanation of algorithm in one sentence:

(c) Sketch the most likely path from Start to Goal for the DistBug algorithm:



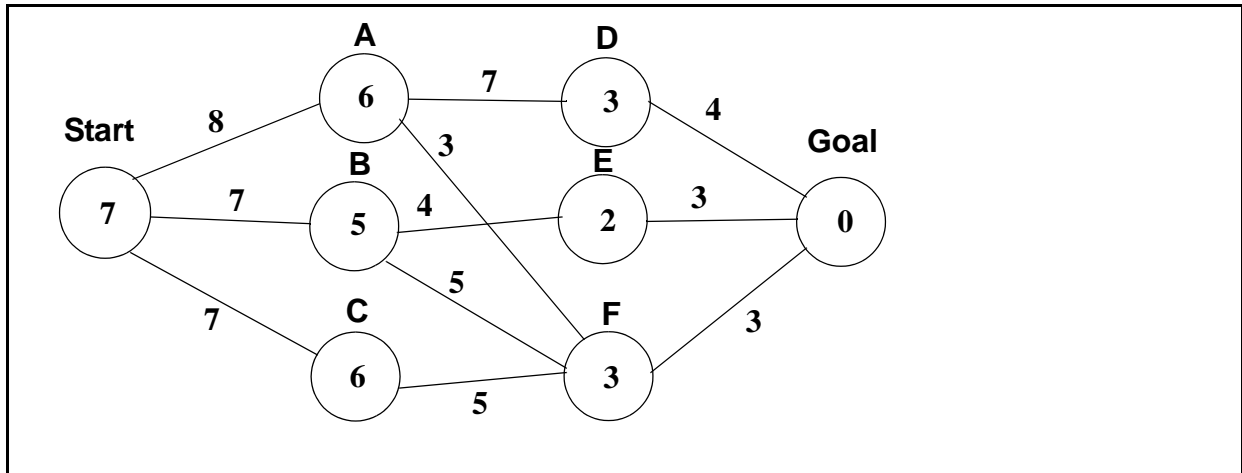
Explanation of algorithm in one sentence:

QUESTION 2

Path Planning

(10+5 = 15 points)

- (a) Apply the A* Algorithm to the following environment graph:
Edge weights are distances between nodes,
Node weights are air-line distances to goal.



Intermediate steps, partial paths:

Shortest Path:

Path Distance:

(b) Which methods do you know for automatic generation of an environment graph from an environment file, e.g. binary image file (name and describe each method with one sentence):

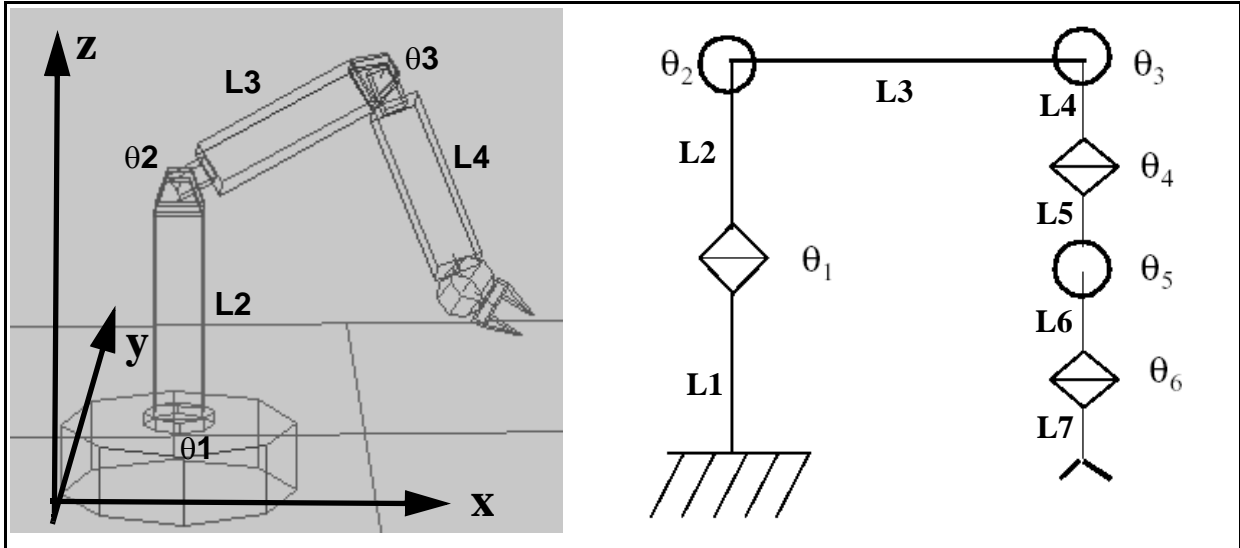


QUESTION 3

Manipulator

(5+10 = 15 points)

Consider the following manipulator, specified as graphics and schematics diagram:



- (a) Assume the robot manipulator forms a straight line in its zero position ($\theta_i = 0$ for all i). Describe the transformation between robot base and tool tip as a formula *expressed in terms of the following operators*:
- Trans (x, y, z)
 - Rot (axis, angle)
- Use $\theta_1 .. \theta_6$ as angle variables and $L_1 .. L_7$ as length constants.

T =

(b) Assume the robot arm has the following dimensions:

$L_1 = 0\text{cm}$, $L_2 = 100\text{cm}$, $L_3 = 50\text{cm}$, $L_4 = 50\text{cm}$, $L_5 = 5\text{cm}$, $L_6 = 5\text{cm}$, $L_7 = 20\text{cm}$

and is in the following configuration:

$\theta_1 = 0^\circ$, $\theta_2 = 90^\circ$, $\theta_3 = 0^\circ$, $\theta_4 = -90^\circ$, $\theta_5 = 0^\circ$, $\theta_6 = 0^\circ$

What is the position of the tool tip?

Calculation:

Result:

QUESTION 4

Kinematics

(5+5 = 10 points)

Consider a differential drive robot with wheel radius 0.1m and wheel distance 0.5m.

- (a) The robot has wheel speeds, $\theta'_{\text{left}} = 1 \text{ rev./s}$, $\theta'_{\text{right}} = 1.5 \text{ rev./s}$
What are its linear and angular velocities?

Answer: $v =$ _____

$\omega =$ _____

- (b) We want the robot to travel with $v = 1 \text{ m/s}$ and $\omega = 30 \text{ deg./s}$
What must its individual rotational wheel speeds be?

Answer: $\theta'_{\text{left}} =$ _____

$\theta'_{\text{right}} =$ _____

QUESTION 5

Intelligent Systems

(6+4 = 10 points)

A mobile robot uses image processing followed by neural network classification for object detection. Image processing delivers 5 feature values that are to be used as input for the neural network. The network has to distinguish 4 different objects.

(a) Sketch the setup of the NN with the appropriate number of input and output nodes. Remember to consider the case that no object has been detected.



(b) Describe the major steps of backpropagation learning (no formulas).

