CS 188 Spring 2014	Introduction to Artificial Intelligence	Written HW1

INSTRUCTIONS

- **Due:** Monday, February 3rd, 2014 11:59 PM
- **Policy:** Can be solved in groups (acknowledge collaborators) but must be written up individually. However, we strongly encourage you to first work alone for about 30 minutes total in order to simulate an exam environment. Late homework will not be accepted.
- **Format:** Submit the answer sheet pdf containing your answers. Page 1 must be this page, with your name, SID, and pandagrader email filled in. Page 2 must contain your answers to question 1 parts a and b. Page 3 must contain your answers to question 1 parts c, d, and e. Page 4 must contain your answers to question 2. You should solve the questions on this handout (either through a pdf annotator, or by printing, then scanning; we recommend the latter to match exam setting). Alternatively, you can typeset a pdf on your own that has answers appearing in the same space (check edx/piazza for latex templating files and instructions). **Make sure that your answers (typed or handwritten) are within the dedicated regions for each question/part. If you do not follow this format, we may deduct points.**
- **How to submit:** Go to www.pandagrader.com. Log in and click on the class CS188 Spring 2014. Click on the submission titled Written HW 1 and upload your pdf containing your answers. If this is your first time using pandagrader, you will have to set your password before logging in the first time. To do so, click on "Forgot your password" on the login page, and enter your email address on file with the registrar's office (usually your @berkeley.edu email address). You will then receive an email with a link to reset your password.

Last Name	Chen
First Name	Jianzhong
SID	23478230
Email	harrychen-cjz@hotmail.com
Collaborators	

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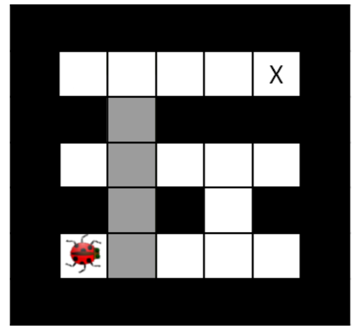
Q. 1	Q. 2	Total
/15	/15	/30

1. (15 points) Question Menagerie

Parts (a) and (b) The hive of insects needs your help again. As before, you control an insect in a rectangular maze-like environment with dimensions $M \times N$, as shown to the right. At each time step, the insect can move into a free adjacent square or stay in its current location. All actions have cost 1.



In this particular case, the insect must pass through a series of partially flooded tunnels. Flooded squares are lightly shaded in the example map shown. The insect can hold its breath for A time steps in a row. Moving into a flooded square requires your insect to expend 1 unit of air, while moving into a free square refills its air supply.

(a) (4 pt) Give a minimal state space for this problem (i.e. do not include extra information). You should answer for a general instance of the problem, not the specific map shown.

Put your answer to 1a here:
A tuple (x,y) for insect position
an int for units of air available

(b) (4 pt) Give the size of your state space.

Put your answer to 1b here:
MNA

Parts (c), (d), and (e) Consider a search problem where all edges have cost 1 and the optimal solution has cost C. Let h be a heuristic which is $\max\{h^* - k, 0\}$, where h^* is the actual cost to the closest goal and k is a nonnegative constant.

(c) (3 pt) Which of the following statements are true?

(i) h is admissible.
(ii) h is consistent.
(iii) A* tree search (no closed list) with h will be optimal.
(iv) A* graph search (with closed list) with h will be optimal.

Put your answer(s) to 1c here:
(i),(ii),(iii),(iv)

(d) (2 pt) Which of the following is the most reasonable description of how much more work will be done (= how many more nodes will be expanded) with heuristic h compared to h^*, as a function of k?

(i) Constant in k

(ii) Linear in k

(iii) Exponential in k

(iv) Unbounded

Put your answer to 1d here:
(ii)

Now consider the same search problem, but with a heuristic h' which is 0 at all states that lie along an optimal path to a goal and h^* elsewhere.

(e) (3 pt) Which of the following statements are true?

(i) h' is admissible.

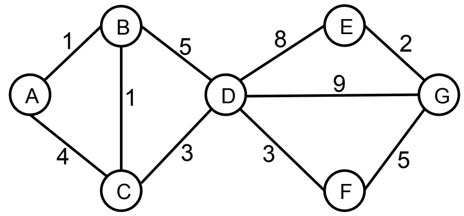
(ii) h' is consistent.

(iii) A* graph search (no closed list) with h' will be optimal.

(iv) A* graph search (with closed list) with h' will be optimal.

Put your answer(s) to 1e here:
(i),(iii),(iv)

2. (15 points) Search



Node	h_1	h_2
A	9.5	10
B	9	12
C	8	10
D	7	8
E	1.5	1
F	4	4.5
G	0	0

Consider the state space graph shown above. A is the start state and G is the goal state. The costs for each edge are shown on the graph. Each edge can be traversed in both directions. Note that the heuristic h_1 is consistent but the heuristic h_2 is not consistent.

(a) [6 pts] **Possible paths returned** For each of the following graph search strategies (*do not answer for tree search*), mark which, if any, of the listed paths it could return. Note that for some search strategies the specific path returned might depend on tie-breaking behavior. In any such cases, make sure to mark *all* paths that could be returned under some tie-breaking scheme.

Search Algorithm	**A-B-D-G**	**A-C-D-G**	**A-B-C-D-F-G**
Depth first search	(i) x	(ii) x	(iii) x
Breadth first search	(iv) x	(v) x	(vi)
Uniform cost search	(vii)	(viii)	(ix) x
A* search with heuristic h_1	(x)	(xi)	(xii) x
A* search with heuristic h_2	(xiii)	(xiv)	(xv) x

(b) Heuristic function properties

Suppose you are completing the new heuristic function h_3 shown below. All the values are fixed except $h_3(B)$.

Node	A	B	C	D	E	F	G
h_3	10	?	9	7	1.5	4.5	0

For each of the following conditions, write the set of values that are possible for $h_3(B)$. For example, to denote all non-negative numbers, write [0, ∞], to denote the empty set, write ∅, and so on.

(i) [2 pts] **What values of $h_3(B)$ make h_3 admissible?**

Put your answer to 2b(i) here:

$[0, 12]$

(ii) [3 pts] **What values of $h_3(B)$ make h_3 consistent?**

Put your answer to 2b(ii) here

$[9, 10]$

(iii) [4 pts] **What values of $h_3(B)$ will cause A* graph search to expand node A, then node C, then node B, then node D in order?**

Put your answer to 2b(iii) here

$[12, 13]$