Midterm Examination

CS540: Introduction to Artificial Intelligence

November 1, 2005 Instructor: Jerry Zhu

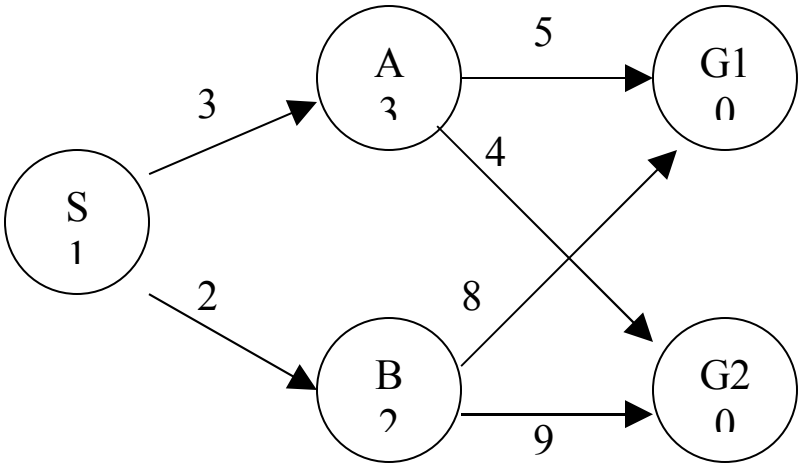
CLOSED BOOK
(One letter-size notes allowed. Turn it in with the exam)

LAST (FAMILY) NAME: _____

FIRST NAME: _____

Problem	Score	Max Score: 5 points each
1	_____	
2	_____	
3	_____	
4	_____	
5	_____	
6	_____	
7	_____	
8	_____	
9	_____	
10	_____	
11	_____	
12	_____	
13	_____	
14	_____	
15	_____	
16	_____	
17	_____	
18	_____	
19	_____	
20	_____	
Total	_____	100

1. A* search
Run A* on the following graph, starting from S. Write done the order of *expanded* states, and determine which goal (G1 or G2) is reached. Numbers on the edges are the edge costs. The heuristic function *h* is shown within each state. Everything being equal, expand states in alphabetical order.



2. Search heuristics
If h1 and h2 are admissible heuristics, circle all admissible heuristics below:

A. 0.1*h1 + 0.9*h2

B. min(h1, h2)

C. min(h1, 2*h2)

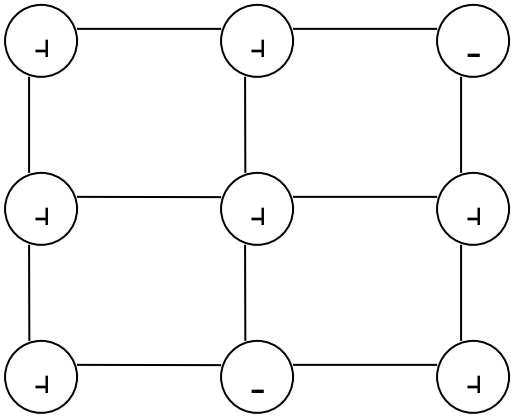
D. min(h1, 0.5*h2)

E. h1 – h2

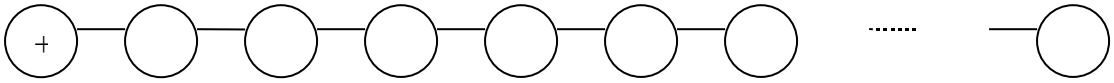
3. Local minimum
In the following graph coloring problem, each node is either labeled + or -. The score of the graph is the number of edges connecting two nodes with the SAME color.

A. If our objective is such that no adjacent nodes have the same color, should we minimize or maximize the score?

B. If the successor function is to change the label of a SINGLE node, in greediest hill climbing which node should we change in the following graph? Mark that node.



4. Constraint Satisfaction Problem
In the following graph with 100 nodes, each node can take label + or -. The constraints are that adjacent nodes cannot have the same label. The left-most node is already labeled +. The remaining nodes have candidate label list {+, -}.



A. If we run forward checking after the left-most node is labeled, what will happen?

B. If we run constraint propagation (2-consistency) after the left-most node is labeled, what will happen?

5. Gradient descent

Assume we want to find the minimum of $f(x)=x^4$. We use gradient descent by iterating

$$x \leftarrow x - 0.1 * f'(x)$$

where 0.1 is the step size, and $f'(x)$ is the derivative of $f(x)$.

A. If we start at x=1, what will happen eventually? You don't have to compute exact numbers for many iterations, instead you should use the trend to answer the question.

B. If we start at x=3, what will happen eventually?

6. Convexity

The function $(x-a)^2$ is convex. So is $(x-b)^2$. The function $2(x-a)^2 - (x-b)^2$ is:

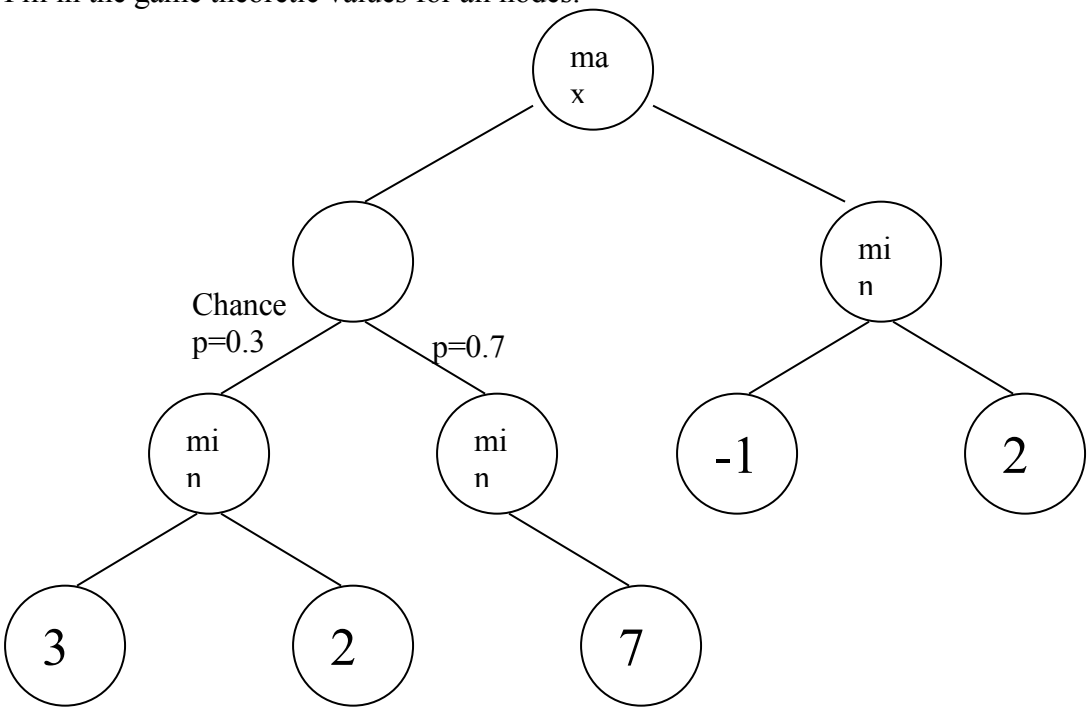
A. always convex

B. always concave

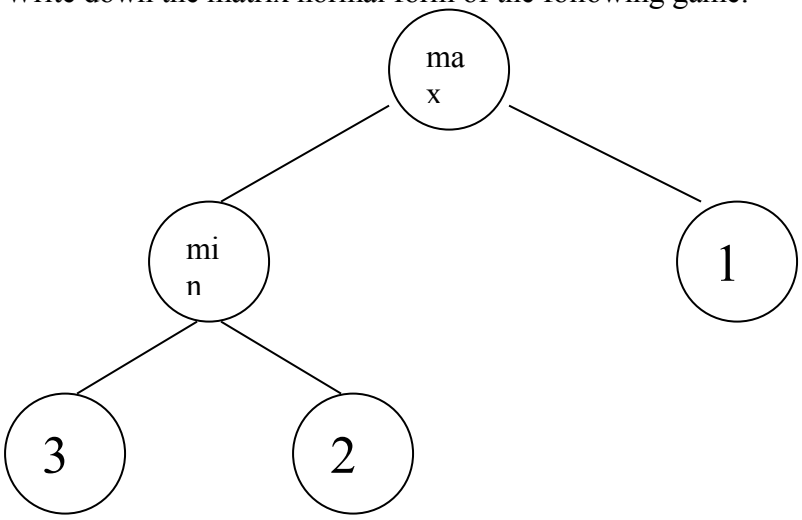
C. sometimes convex and sometimes concave, depending on the values a, b

D. none of above

7. Game Tree with Chance node
Fill in the game theoretic values for all nodes.



8. Matrix normal form of game
Write down the matrix normal form of the following game:



9. Mixed strategies in game
For the following zero-sum game, if A plays with mixed strategy (1/3, 1/3, 1/3), and B plays with mixed strategy (1/2, 1/2), what is the game theoretic value for A?

	B	
A	-1	-1
	-2	3
	2	2

10. Dominate strategy
Perform iterative elimination of strictly dominated strategies on the following MNF for non-zero sum game:

6, 3	7, 9	1, 7	4, 9
9, 2	6, 4	2, 2	3, 3
9, 4	8, 6	7, 4	5, 6
5, 6	5, 8	0, 5	3, 4

11. Nash equilibrium
Circle all Nash equilibria in the following zero-sum game:

9	2	8
3	6	9
8	7	10

12. Propositional logic
We define a new propositional logic connective ☺, which has the following truth table:

P	Q	P ☺ Q
T	T	F
T	F	T
F	T	F
F	F	F

Write down the truth table for (P ☺ Q) ☺ (Q ☺ P).

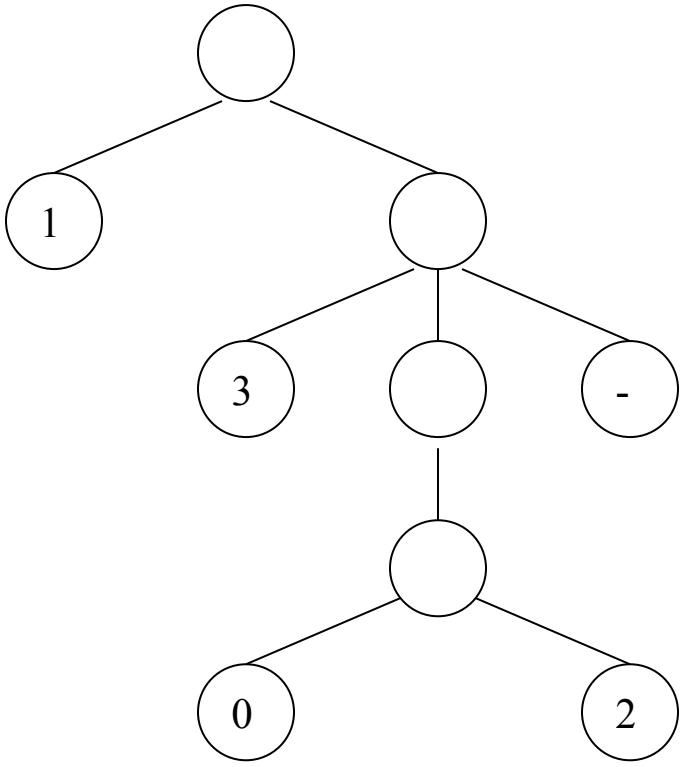
13. Unification
Write down the Most General Unifier for the following pairs of FOL clauses. A, B are objects and x, y, z are variables.

A. middle(left(x), x, right(x)), middle(left(A), A, y)

B. middle(left(x), x, right(x)), middle(left(y), A, z)

C. middle(left(x), x, right(B)), middle(left(y), A, right(y))

14. alpha-beta pruning
Perform alpha-beta pruning on the following game tree. Write down the game theoretic value, alpha, beta for applicable nodes, and mark which branches are pruned. As usual the root node is max.



15. Propositional logic
Given the propositional logic KB:

$P \Rightarrow Q$
$\neg (R \Rightarrow Q)$

Use resolution refutation to prove $\neg (R \Rightarrow P)$. Clearly write down all the steps.

16. English to FOL
The English sentence:

"I saw the duck in the park with a telescope."

is famous for its ambiguity. We have defined the following objects and predicates for you:

I, Duck, Park, Telescope
V(x, y, z): x visually detected y using device z
L(x,y): x is located in y
P(x,y): x possesses y

As an example, this is one possible (although somewhat unusual) FOL interpretation of the original sentence, and its English re-interpretation:

$\exists x\ V(I, Duck, x) \wedge L(Duck, Park) \wedge P(Duck, Telescope)$
I saw the duck (using some device – maybe just my eyes), the duck is in the park, and the duck has a telescope.

Write down 5 more different FOL interpretations of the original sentence. You do not have to re-interpret them in English. You may define new predicates if necessary.

1.

2.

3.

4.

5.

17. FOL backward chaining
Given the FOL KB:

above(x, z) $\wedge$ ontop(z, y) $\Rightarrow$ above(x, y)
ontop(x, y) $\Rightarrow$ above(x, y)
ontop(A, B)
ontop(B, C)

When proving above(A, C), what might happen if we always scan the KB from top to bottom, and apply the first rule in the KB whose right-hand-side matches the sub-goal we are trying to prove?

18. Propositional logic
Show that the following KB is inconsistent. You can use and mix whatever sound rules (e.g. Modus Ponens, resolution).

1. $\neg$ (A $\Rightarrow$ D)
2. A $\Rightarrow$ B
3. E $\Rightarrow$ $\neg$ (D $\Rightarrow$ C)
4. (B $\wedge$ A) $\Rightarrow$ E

19. Uninformed search
In uniform cost search, can we have a few edges with negative weights in the graph?
A. No, it will surly screw things up
B. Yes, it doesn't matter
C. It depends
Be sure to justify your answer.

20. In GoogSoft, software engineers A and B form a two-person team. Their year-end bonus depends on their relative performance. A is slightly better than B, but A wants to work less. Explicitly A and B notice the following bonus outcome:

	B-works hard	B-slacks
A-works hard	9, 7	10, 0
A-slacks	0, 10	9, 9

A. If A and B act rationally, which actions will they take? What is the outcome?

B. How can A and B minimize their work?

C. As A and B's manager, what can you do to prevent A and B from slacking?

(scratch paper)