CS 2710 / ISSP 2160: Artificial Intelligence
MIDTERM EXAM (Fall 2006)

This exam is closed book and closed notes. It consists of three parts. Each part is labeled with the amount of time you should expect to spend on it. If you are spending too much time, skip it and go on, coming back if you have time. The first part is multiple choice. The second part is short answer and problem solving. The third part is an essay.

Part I - Multiple Choice. 20 points total. 15 minutes.

Circle *the one* answer that best answers the question.

1. Which of the following search algorithms is *not* informed search?

a. greedy search
b. iterative deepening
c. A^*
d. hill-climbing search

2. In which of the following search algorithms is it possible to confuse a local maximum with a global maximum?

a. depth first
b. A^*
c. hill climbing
d. greedy search

3. An *optimal* search algorithm

a. finds the solution that has the lowest path cost among all solutions
b. finds all solutions
c. finds a solution using the least amount of memory
d. is guaranteed to find a solution when there is one

4. A semantic network

a. is a graph-based representation where nodes represent concepts and arcs represent relations
b. is a graph-based representation where nodes represent relations and arcs represent concepts
c. represents an entity as a set of slots and associated values
d. is a subset of the situation calculus

5. An ontology

a. represents an entity as a set of slots and associated values
b. is a subset of first-order logic
c. is an inference mechanism
d. provides a vocabulary for expressing knowledge

6. An inference procedure

a. is a declarative knowledge representation
b. provides rules for deriving new facts from existing facts
c. is a proof
d. is a type of inheritance

7. An inference method is *sound* if it

a. can derive any sentence that is entailed
b. only derives entailed sentences
c. is efficient in both time and space
d. is not NP-complete

8. An inference method is *complete* if it

a. can derive any sentence that is entailed
b. only derives entailed sentences
c. is efficient in both time and space
d. is not NP-complete.

9. A zero-sum game is one in which

a. the feature weights in an evaluation function must sum to zero.
b. the points in any one player's hand must sum to zero.
c. if one player wins, the other necessarily loses.
d. two players may team up to beat a third.

10. Uniform cost search is A* search with

a. f(n)=h(n)
b. f(n)=g(n)+h(n)
c. h(n)=0 for all n
d. h(n) being an admissible heuristic

Part II. Problem Solving. 70 points. 50 minutes.

1. **[15 points]** Consider the *n*-queens problem, which requires the placement of *n* queens on an *n* x *n* chess board such that no queen is on the same row, column, or diagonal as any other.

A. (9 pts) Formalize the **4-queens problem** as a constraint satisfaction problem. (You only need to exhaustively list the constraints for one of the types of constraints that you include in the CSP. Any additional types of constraints can be explained briefly in words rather than equations.)

B. (4 pts) Show the constraint graph for your CSP formalization from part 1.

C. (2 pts) Name the *uninformed* search algorithm that is typically employed to solve CSPs?

2. [20 points] Resolution Search.

Knowledge Base:

Fido is a dog.

Rules:

All dogs are animals.
All animals drink water.

Goal: Fido drinks water.

A. Convert these sentences to *First-Order* Logic. (Remember to define all predicates, functions, and constants.)

B. Put the resulting sentences into Conjunctive Normal Form.

C. Using proof by refutation and resolution as the single inference rule, show the resolution proof that proves or disproves the goal (show any unifications required).

3. [20 points] Consider the following formulation of the monkey and bananas problem. The world contains a monkey, a box, and a bunch of bananas; the monkey and box are initially on the floor, while the bananas are initially on the ceiling. We'll use the notation *holds(?p, ?s)* to indicate proposition *?p* is true in situation *?s* (where the leading ? indicates a variable); and *result(?o, ?s)* indicates the new situation that results after applying operator *?o* in prior situation *?s*. The initial situation is denoted s0, and the three distinct locations in this world are labeled loc0, loc1, and loc2.

Provide a first order situation-calculus formulation of this problem, by providing axioms that formally describe:

A. (5 points) The initial state of the world where the monkey is at loc0, the box is at loc1, the bananas are at loc2, the monkey is on the floor, the box is on the floor, and the bananas are on the ceiling.

B. (10 points) The operators available to change the state of the world: *MOVE, PUSH, CLIMB, AND GRAB*.

Use the special situationless predicates *differs* and *connected* in your axioms. You can assume *differs* is appropriately defined and that all locations are appropriately interconnected; thus, *connected(?l1, ?l2)* is true for all *?l1, ?l2* when *differs (?l1,?l2)* is true, i.e., a given location is never connected to itself.

C. (5 points) We would like to use a theorem prover (or any deductive inference system) to derive plans with this set of axioms. Unfortunately, there is something lacking in our "domain theory," i.e. in our formulation of the monkeys and bananas world. Provide the common name for the problem that we will encounter and describe it briefly.

(continue answer here if needed)

4. [15 points] Consider the search space below, where S is the start node and G1 and G2 are goal nodes. Arcs are labeled with the value of a *cost function*; the number gives the cost of traversing the arc. Nodes are labeled with the value of a *heuristic function*; the number gives the estimate of the distance to the goal. Assume that uninformed search algorithms always choose the left branch first when there is a choice.

For each of the following search strategies, indicate 1. which goal state is reached first (if any) and 2. list *in order,* all the states that are popped off the OPEN list.

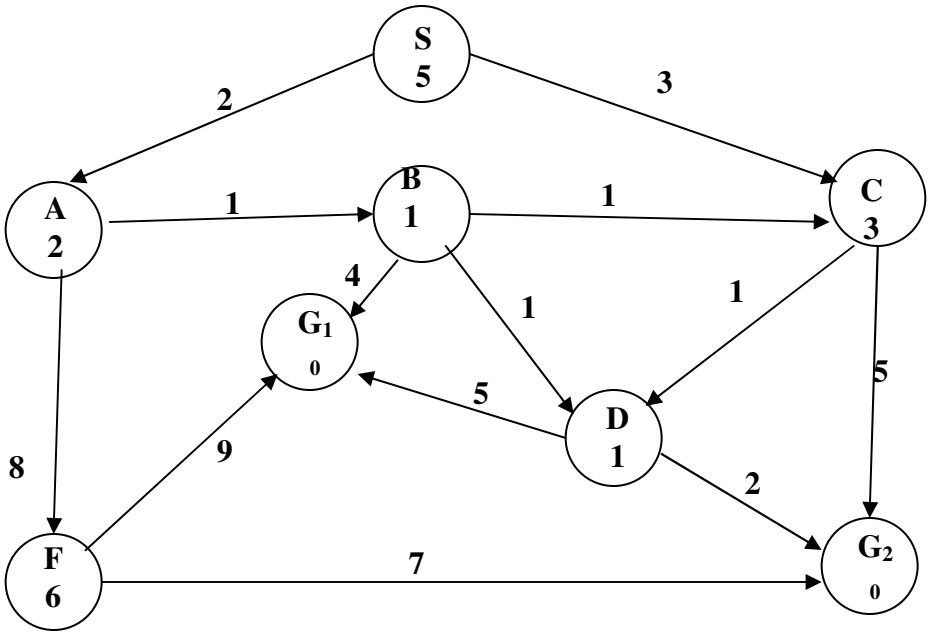
Depth-first

Iterative Deepening

Breadth-first

Greedy

A*


S
5
2
3
A
2
1
B
1
1
C
3
4
1
1
5
G1
0
5
D
1
8
9
2
F
6
7
G2
0

`

Part III. Short Answer. 10 points. 10 minutes.

A. Suppose h1 and h2 are admissible heuristics. Suppose we are using A*-search. Why is it a good idea to use max(h1,h2) rather than either h1 or h2 alone as the heuristic evaluation function? Please explains your answer. Consider the optimality and efficiency of the search.

B.What is the difference between propositional logic, Horn clauses, and first order logic? When/why would you want to use one versus the other?