CS 540: Introduction to Artificial Intelligence

Midterm Exam: 7:00-9:00 pm, October 28, 1999
Room 105 Psychology

CLOSED BOOK
(one sheet of notes allowed)

Write your answers on these pages and show your work. If you feel that a question is not fully specified, state any assumptions you need to make in order to solve the problem. You may use the backs of these sheets for scratch work.

Write your name on this and all other pages of this exam. Make sure your exam contains nine problems on seven pages.

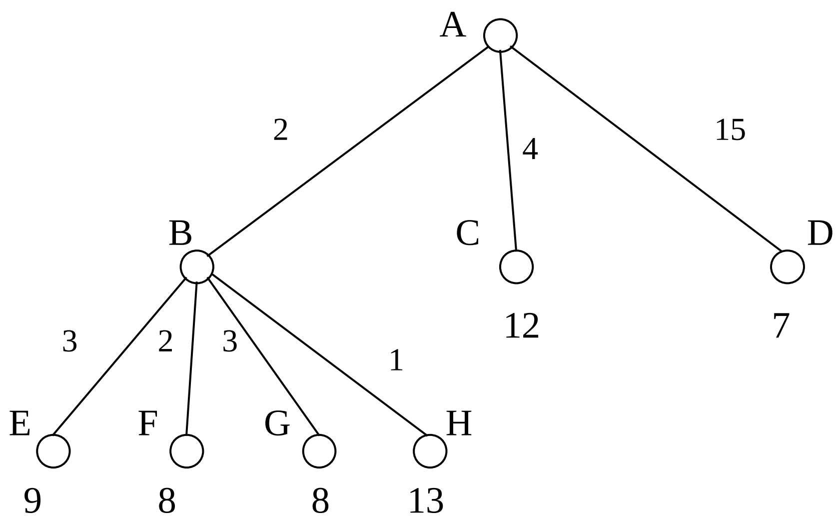
Name ____

Student ID ____

Problem	**Score**	**Max Score**
1	______	**21**
2	______	**5**
3	______	**12**
4	______	**14**
5	______	**10**
6	______	**6**
7	______	**5**
8	______	**17**
9	______	**10**
TOTAL	______	**100**

Problem 1 – Search [21 points]

The following figure shows a partially expanded search tree each arc is labelled with the cost of the corresponding operator, and the leaves are labelled with the value of the heuristic function h. Which node will be **expanded** next by each of the following search methods?



a) [3] Breadth-first search

b) [3] Depth-first search

c) [3] Greedy search

d) [3] Uniform cost search

e) [3] A* search

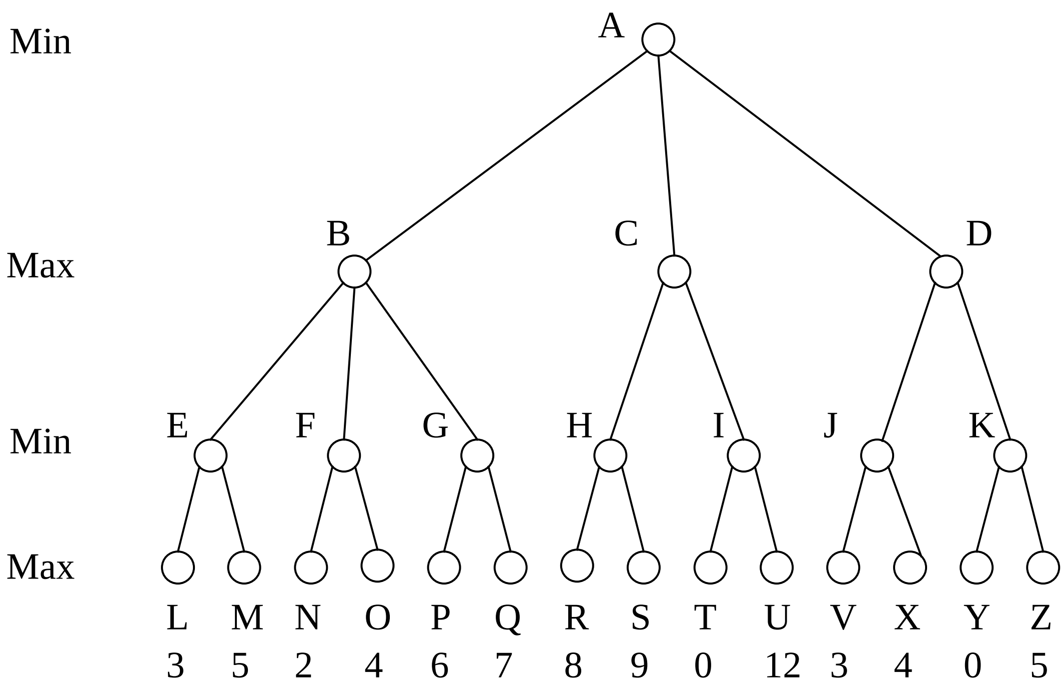
f) [3] Iterative-deepening search (assume that you are at level 2)

g) [3] Iterative-deepening search (assume that you are at level 3)

Problem 2 – Search [5 points]
What is the benefit of using iterative deepening?

Problem 3 – Alpha-Beta Search (12 points)

Consider the following game tree in which the static evaluation function values are shown below each leaf node. Assume that the root node correspond to the minimizing player. Assume the search always visits children left-to-right.



a) [5] Compute the final backed-up values computed by the alpha-beta algorithm. Show your answer by writing values at the appropriate nodes in the above tree.

b) [5] What nodes are not examined by alpha-beta?

c) [2] What move should Min choose?

Problem 4 – Propositional Logic [14 points]

$\models ((P \wedge Q) \rightarrow R) \leftrightarrow (\neg (P \wedge Q) \vee R)$? Answer it using a truth-table [10].

Transform the following formulas into Conjunctive Normal Form (CNF) and also into Implicative Normal Form (INF):

a) [2] $(P \rightarrow Q) \rightarrow R$

b) [2] $P \rightarrow (Q \rightarrow R)$

Problem 5 – First-Order Logic (10 points)

Convert each of the following English sentences into First-Order Logic (the first four will be our Knowledge Base and the last one will be our Query), using reasonably named predicates, functions, and constants. If you feel a sentence is ambiguous, clarify which meaning you're representing in logic.

Fathers and mothers like children.

Norman is a father who does not like Peter

No mother likes Sarah

Rita is a mother

Neither Peter nor Sarah are children

Problem 6 – Unification [6 points]

For each of the following, give a **most general unifier**, if it exists or write it does not unify.

a) $\{P(g(y, f(A)), f(z)) , P(x, f(x))\}$

b) $\{Q(B, g(x, A), x) , Q(B, g(y, A), f(y, C))\}$

Problem 7 – Skolemize [5] :

$\forall z\ \forall x\ (\exists y\ (P(x , y, z)) \vee \exists w \forall v(Q(w, v, x, z)) \vee\ \exists t\ R(t)\ )$

Problem 8 – First-Order Resolution [17 Points]

[2] Can we apply resolution to these two clauses below (father_of and mother_of are function symbols)? If so give the resolvent.

1. $\neg$Professor(x) $\vee$ Professor(father_of(x)) $\vee$ Professor(mother_of(x))
2. $\neg$Professor(x) $\vee$ $\neg$Rich(x)

[10] Let S' be the following set of clauses in INF; use linear resolution (start with clause 7) to show that there is a refutation from S' (S' |- $\rightarrow$). ($\rightarrow$ is the empty clause)

1. $(P(x) \wedge Q(y)) \rightarrow R(x, y)$
2. $(S(u) \wedge Q(v)) \rightarrow R(u, v)$
3. $(S(z) \wedge R(z, A)) \rightarrow$
4. $\rightarrow S(D)$
5. $\rightarrow P(C)$
6. $R(C, B) \rightarrow$
7. $\rightarrow Q(A) \vee Q(B)$

[5] Based on your previous answer, why can we conclude that KB |= G, where KB is a set of formulas and G a formula that originated S'? Answer using the necessary theorems.

Problem 9 – Miscelaneous questions [10 points]

Answer each of the following *True* (T) or *False* (F).

1. [2] If you have two admissible heuristics h1, h2, such that:
   for every node n, h2(n) ≥ h1, and there exists a node j such that h2(j)> h1,
   then h1 is always more efficient than h2.

2. [2] It is often the case that the cost of an exact solution to a relaxed problem is a good heuristic for the original problem.

3. [2] In Constraint Satisfaction Problems (CSP), variable and value ordering heuristics can provide huge performance gain.

4. [1] The resolvent of $\neg P \vee \neg Q$ and $P \vee Q$ is not the empty clause.

5. [1] Any FOL formula is logically equivalent to its CNF.

6. [2] We can always use resolution to decide if a set of FOL clauses is satisfiable.