CS 540:
Introduction to Artificial Intelligence

Midterm Exam: 1:10-3:10 pm, July 10, 2003
Room 265 Materials Sciences Building

CLOSED BOOK
(one-sided sheet of handwritten notes and a calculator 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. Budget your time wisely.

Before you begin, write your name on every page of the exam and read through all the questions (as some have multiple parts and are more involved than others). Make sure your exam contains ***eight (8)*** problems on ***ten (10)*** pages.

Name ____

Student ID ____

Problem	Score	Max Score
1	______	10
2	______	20
3	______	10
4	______	10
5	______	15
6	______	10
7	______	15
8	______	10
TOTAL	______	100

Name: ________________________________

Problem 1: Agents and Environments (10 points)

a) Draw a diagram of a simple agent architecture and how it interfaces with its environment. Be sure to include a model of the world, prior knowledge, and goals.

b) Devise and describe a problem environment. Characterize it in terms of the features discussed in class (e.g. fully/partially observable, etc.). If a characteristic is ambiguous for this environment, explain why.

Name: ______________________________

Problem 2: General Search (20 points)

a) Consider the search graph below, where *S* is the start node and *G1*, *G2*, and *G3* satisfy the goal test. Arcs are labeled with the cost of traversing them and the estimated cost to a goal (heuristic evaluation) is reported inside nodes.

For each of the following search strategies, indicate which goal state is reached (if any) and list, in order, all the states *removed from* the OPEN list (i.e. the order they are expanded). When all else is equal, nodes should be *inserted into* the OPEN list in alphabetical order.

Breadth-First Search

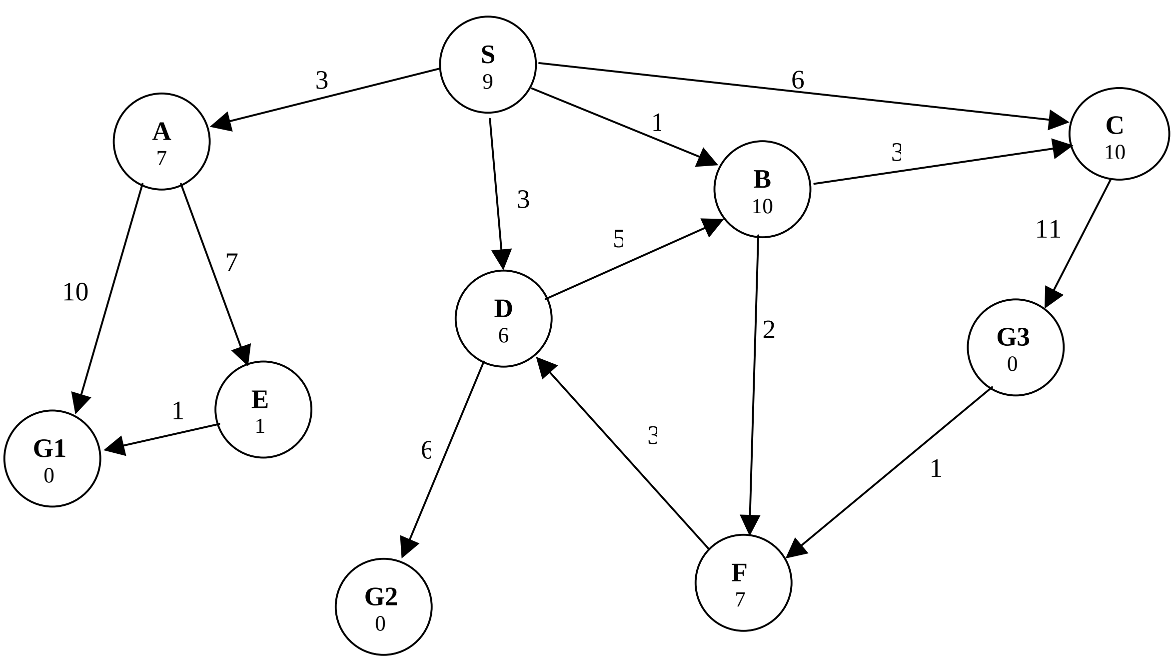
Goal state reached: ________ States removed from OPEN: ______________________________

Uniform Cost Search

Goal state reached: ________ States removed from OPEN: ______________________________

A* Search

Goal state reached: ________ States removed from OPEN: ______________________________



Name: ______________________________

b) Note: these questions are about searching *in general* and do *not* refer to the graph from part a.

i. Consider a heuristic that always evaluates to $h(n) = 1$ for non-goal search nodes. Under what conditions is it admissible?

ii. Do breadth-first search and iterative-deeping search always find the same solution? Why or why not?

iii. Given two admissible heuristic functions h_1 and h_2, which composite heuristic function is better: (h_1+h_2) or $(h_1+h_2)/2$? Why?

iv. What is the main difference between greedy search and algorithm A search?

v. Consider the evaluation function: $f(n) = \alpha \times g(n) + (1-\alpha) \times h(n)$. What range of values for α will result in a guaranteed optimal search strategy? Explain your answer.

Name: ______________________________

Problem 3: Local and Evolutionary Search (10 points)

a) Provide a short response to each of the following:

   i. Describe two conditions where hill-climbing will find the global optimum.

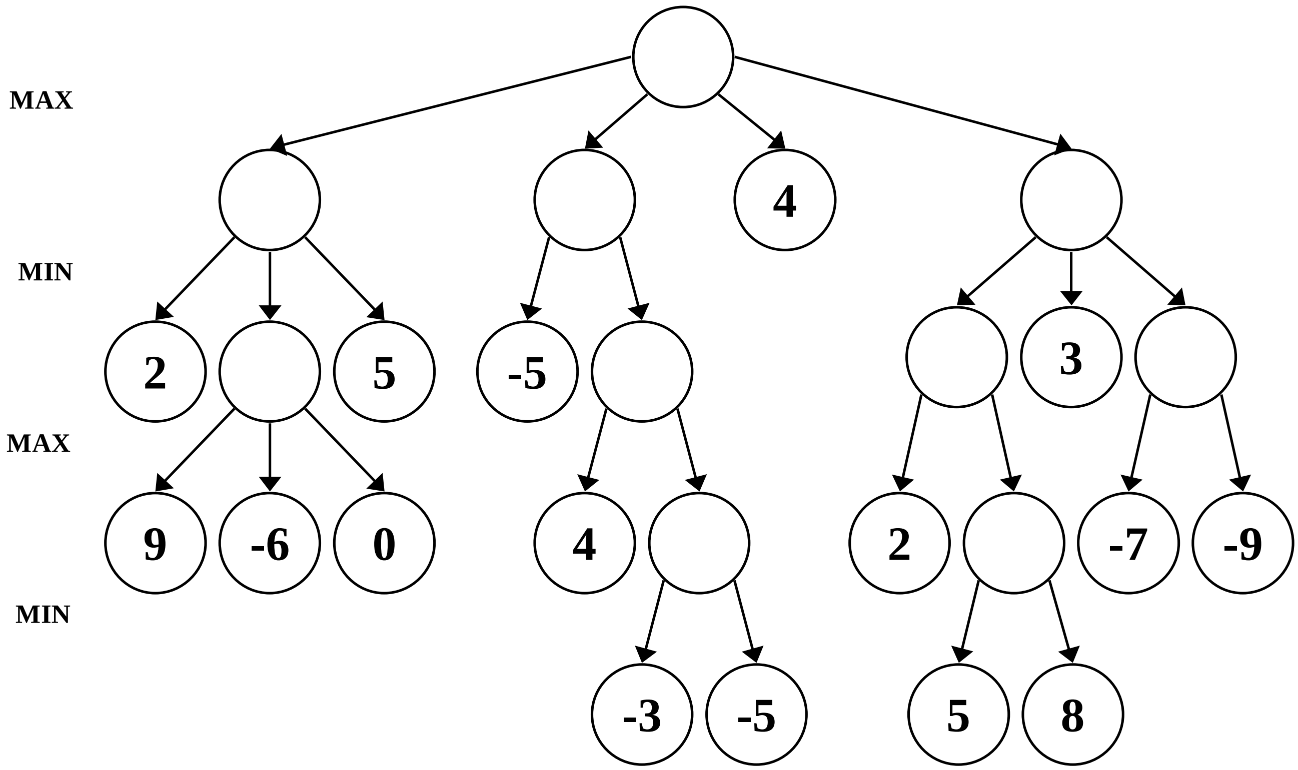
   ii. Give one similarity and one difference between simulated annealing and tabu search.

b) Name and define three different ways of performing a cross-over for a genetic algorithm solving the SAT problem (you may provide specific examples for clarification if you wish).

Name: ________________________________

Problem 4: Game Playing (10 points)

a) Perform an Alpha-Beta search on the following game tree, going from left to right. Report the final α and β values for all the intermediate game nodes, and indicate which nodes are pruned by crossing them out. Circle the move the computer should make.



b) Briefly describe the horizon effect. What is one technique we can use to avoid it?

Name: ______________________________

Problem 5: Propositional Logic (15 points)

a) Answer each of the following questions *true* or *false*:

i. Inference by enumeration is sound, but incomplete for PL.

ii. $((A \Rightarrow B) \Rightarrow A) \Rightarrow A$ is a valid sentence.

iii. $((A \vee B) \wedge \neg B) \Leftrightarrow A$ has the same number of models as $((A \Rightarrow B) \wedge A) \Leftrightarrow B$ for any fixed set of propositions A and B.

iv. $(A \wedge \neg B) \Rightarrow \neg C$ can be converted to an equivalent set of horn clauses.

v. $(A \Rightarrow B) \vee C$ can be converted to an equivalent set of horn clauses.

b) Formally derive E from the KB below using natural deduction with inference rules. (Deduce no more than 10 additional sentences.)

Number	**Sentence**	**Inference Rule Used**
1.	$A \wedge B$	(given)
2.	$(\neg C \wedge \neg D) \vee (\neg A)$	(given)
3.	$F \vee D$	(given)
4.	$(D \wedge F) \Rightarrow A$	(given)
5.	$F \Rightarrow (E \vee A)$	(given)
6.	$(A \wedge F) \Rightarrow (E \vee C)$	(given)

Name: ______________________________

Problem 6: Thinking in First-Order Logic (10 points)

Translate each of the following English sentences into first-order logic (FOL), using reasonably named predicates, functions, and constants. If you feel a sentence is ambiguous, clarify which meaning you're representing in logic. (Write your answer in the space *below* the English sentence.)

Jack is nimble, but Jill is not.

Someone in Wisconsin likes the Packers.

All students who take CS-540 understand logic.

Everyone who owns a computer knows someone who can fix it.

There are exactly two sith: one master, and one apprentice.

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Problem 7: First-Order Inference (15 points)

Consider the following two English sentences and their FOL translations:

P: "Anything is valuable if somebody loves it."
$\forall y\ [\exists x\ \text{loves}(x,y)] \Rightarrow \text{valuable}(y)$

Q: "Everything loved by everyone is valuable."
$\forall y\ [\forall x\ \text{loves}(x,y)] \Rightarrow \text{valuable}(y)$

Using resolution refutation, show that sentence **P** entails sentence **Q**. Convert to conjunctive normal form (CNF), construct a proof tree, and show the substitutions at each step.

Name: ______________________________

Problem 8: Miscellaneous Short Answer (10 points)

Briefly define the following concepts and explain the significance of each to A.I.
(Write your answer *below* the phrase.)

Situatedness

Lamarkian Theory

SBE Functions

Soundness

Backward Chaining