(PRINT) Name ____Student No__________

Signature ____Total Mark_____/100

University of Waterloo

Computer Science 486/686 – Introduction to Artificial Intelligence

Midterm Test
2014 March 6
Time: 8:35 am – 9:50 am

Time: 75 minutes
Total marks: 100

Answer all questions on this paper. No books or other materials may be used. Non-programmable calculators are permitted but not personal computers.

This examination has 7 pages. Check that you have a complete paper.

1	**/ 28**
2	**/ 24**
3	**/ 24**
4	**/ 24**
Total	**/ 100**

Question 1 [28 pts] Search techniques

a) [16 pts] Consider the following generic search procedure:

1. Let $PQ = \{s\}$ i.e., priority queue consists of the start state
2. Loop until priority queue is empty
    a. Remove the first node n from PQ
    b. If n is a goal state then stop; report success
    c. Otherwise add each neighbour of n to PQ

Briefly explain how nodes should be added to the priority queue (step 2c) to emulate each of the following algorithms.

i) [4 pts] Depth-first search

ii) [4 pts] Breadth-first search

iii) [4 pts] Greedy best-first search

iv) [4 pts] A* search

b) [12 pts] Constraint satisfaction problems consist of finding an assignment of values to a set of variables that satisfies a set of constraints. Instead of solving the problem by backtracking search, you'd like to tackle the problem with a hill climbing algorithm. Describe a hill climbing algorithm that could operate on any constraint satisfaction problem. More precisely, describe the state space, the move set and the objective used by your hill climbing algorithm. Describe also the rule used to select a move at each step.

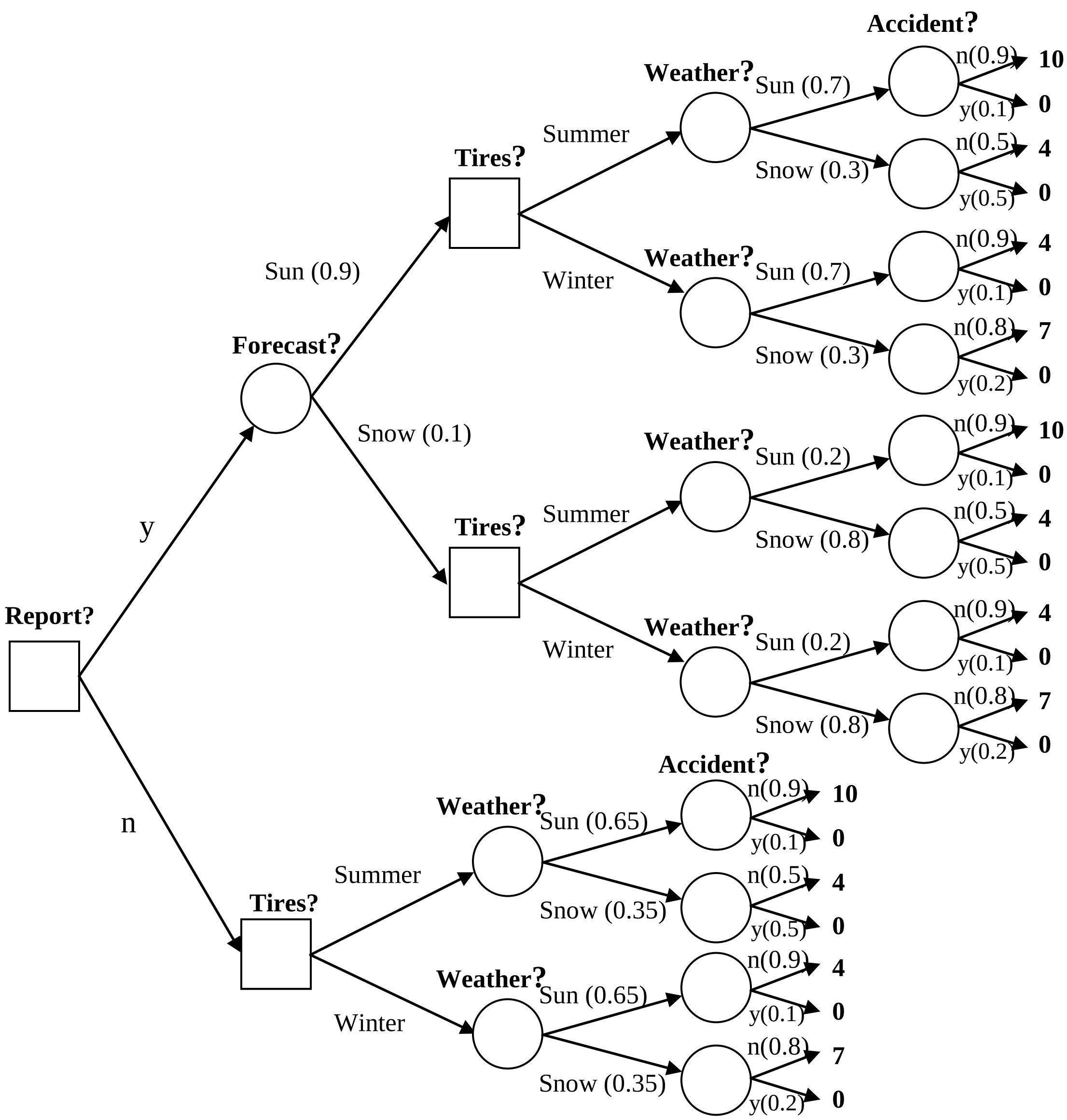
i) [3 pts] state space:

ii) [3 pts] Move set:

iii) [3 pts] Objective:

iv) [3 pts] Rule to select the next move:

Question 2 [24 pts] You are planning a road trip, and depending on the weather you may choose winter tires or summer tires. If you choose summer tires and it is snowing, your chances of an accident are higher, but if you pick winter tires and the road is dry, your performance decreases (fuel/tire consumption). Before leaving on your trip, you can consult a weather report to help you make your decision, however this report may not be totally accurate. In order to maximize the utility of your trip (i.e., having a safe and economical trip) you decide to use the following decision tree. Squares are decision nodes and circles are chance nodes. Arcs going out of a chance node are labeled with a probability and the numbers in bold at the leaves are the utility values.



a) [8 pts] Fill in the decision and chance nodes with their expected utility values.

b) [4 pts] What is the policy that maximizes expected utility? Write it in *simple* English.

c) [6 pts] What is the accuracy of the weather report? In other words, what is the probability that the forecast is accurate?

d) [6 pts] How valuable is the weather report? In other words, up to how much utility would you be willing to “pay” to get the forecast?

Question 3 [24 pts] Are the following statements true or false? No justification required.

a) [3 pts] Since GPS doesn't work indoors, a mobile robot can avoid getting lost simply by keeping track of its movements based on an odometer.

b) [3 pts] Admissible heuristics are necessarily consistent.

c) [3 pts] All search algorithms take exponential time in the worst case.

d) [3 pts] Variable elimination takes exponential time in the worst case.

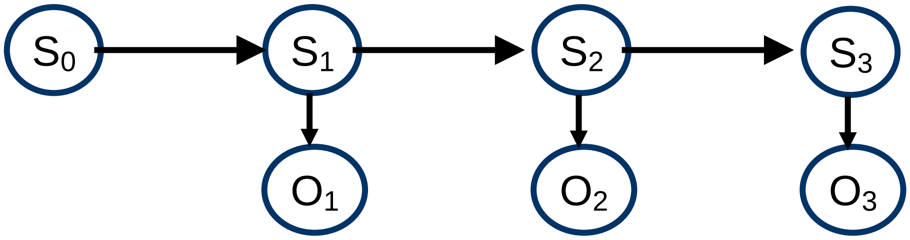
e) [3 pts] In a decision network, edges that point to a decision node indicate decision dependencies.

f) [3 pts] For any preference ordering, there is an infinite number of equivalent utility functions.

g) [3 pts] When probabilities are used to denote the "degree of belief" in some event, probabilities are subjective and therefore it is possible that different people assign different probabilities to the same event.

h) [3 pts] Likelihood weighting requires fewer samples than rejection sampling to achieve the same accuracy since none of the samples are rejected in likelihood weighting.

4) [24 pts] Consider a first-order hidden Markov model.



a) [8 pts] A hidden Markov model can be viewed as a Bayesian network with the same structure that repeats at each time step. Normally, when specifying a Bayesian network, we need to provide a conditional probability table for each variable in the network. However, an HMM can be completely specified by providing $Pr(S_t|S_{t-1})$, $Pr(O_t|S_t)$ and $Pr(S_0)$. What assumption allows us to specify an HMM with those three distributions only? Explain briefly.

b) [8 pts] Conditional independence:

i) [4 pts] Is S_3 independent of S_1 given S_2? Explain briefly

ii) [4 pts] Is O_3 independent of O_1 given O_2? Explain briefly.

c) [8 pts] Suppose you want to predict S_3 based on O_1 only (i.e., $Pr(S_3|O_1)$). What are the relevant and irrelevant variables for this query?