NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING

EXAMINATION FOR

Semester 1 AY2009/2010

CS3243: FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

23rd November 2009 Time Allowed: 2 Hour

INSTRUCTIONS TO CANDIUADTES:

1. This examination paper contains **Six (6)** questions and comprises **Four (4)** printed pages, including this page.
2. Answer **ALL** questions on the answer book provided.
3. The total mark of this paper is 35.
4. This is an Open Book examination.

Good Luck!

QUESTION 1 - Searching *(4 Marks)*

Figure 1 shows a partially expanded search tree. Each arc is labeled with the corresponding step cost; all the leaves are labeled with their heuristic evaluation cost. Suppose that we are in the node A.

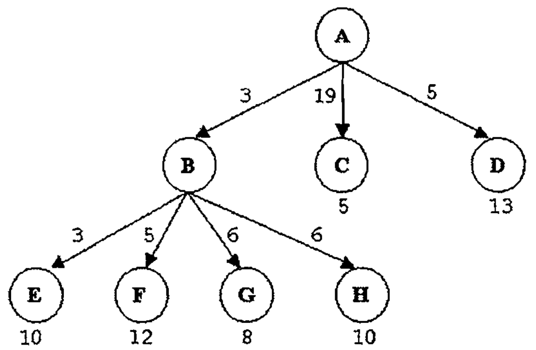

Figure 1

a) Show which leaf will be expanded next by using the following search methods. Note that you need to show the sequence of nodes (and their costs) being expanded before expanding the leaf node: *(3 Marks)*

   i) The greedy best-first search,

   ii) The uniform-cost search,

   iii) The A* search.

b) Discuss the properties of algorithms in terms of completeness and optimality in finding the solutions. *(1 Marks)*

QUESTION 2: First Order Logic *(5 Marks)*

Expand the following English sentences in FOL expressions.

a) Some students took CS3243 in Semester 1 of 2008 (Seml-08). You may use the function Take(person, course, semester) to denote <person> take <course> in (semester>.

b) Every student who takes CS3243 in Semester 1 of 2009 passes it.

c) Everyone who eats pizza is either a youngster, Foreigner or a busy graduate student.

d) There is at least one student who doesn't hate (any of) programming assignments for the computing courses.

e) Brother-in-law (your spouse's brother)

QUESTION 3: First Order Logic *(5 Marks)*

Consider the following set of axioms:

1. $\forall$ x [equal(x,x)]
2. $\forall$ y,z [equal(y,z) $\Rightarrow$ equal(z,y)]
3. $\forall$ w,s,t [equal(w,s) $\wedge$ equal(s,t) $\Rightarrow$ equal(w,t)]
4. equal(b,a)
5. equal(b,c)

and the conclusion:

equal(c,a)

As usual, *a, b, c* denote constants and *x, y, z, w, s, t* variables. Prove the conclusion from the axioms by refutation using resolution.

QUESTION 4: Inductive learning *(7 Marks)*

Given the following six training examples:

Example	**Color**	**Shape**	**Size**	**Class**
1	red	square	big	+
2	blue	square	big	+
3	red	round	small	-
4	green	square	small	-
5	red	round	big	+
6	green	square	big	-

a) Compute the complete corresponding decision tree, based on the ***largest*** expected ***information gain*** of critical (decisive) attribute. Need to clearly show the detailed working. *(3 Marks)*

b) Express the problem as a Naïve Bayesian learning problem. Show the required equations and provide the estimates of probabilities needed for the Naïve Bayesian classification. *(4 Marks)*

QUESTION 5: Bayes networks *(5 Marks)*

Match the probabilistic networks shown in Figure 2 with one or more of the given statements below. If there are multiple matchings, list them as well. Note that not all statements must be matched.

a) P(C|A,B) = P(C|A)
b) P(C|A,B) = P(C|B)
c) P(B|A) = P(B)
d) P(B,C|A) = P(B|A) P(C|A)

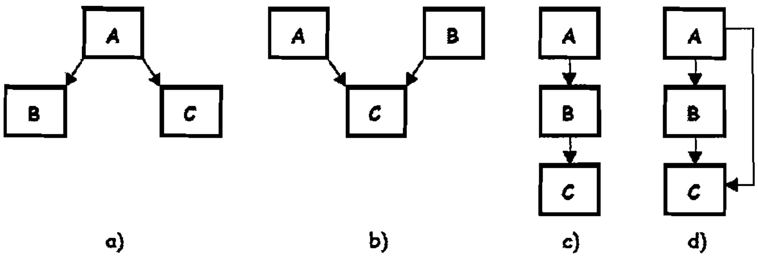

Figure 2

QUESTION 6: Planning *(9 Marks)*

Consider a planning problem involving a simple Tower of Hanoi domain with 2 disks - one large and one small and 3 pegs. Figure 3(a) shows the initial state and Figure 3(b) shows the goal state. The list of variables in this problem is SMALL (small disc), LARGE (large disc) and three pegs, Peg1, Peg2 and Peg3.

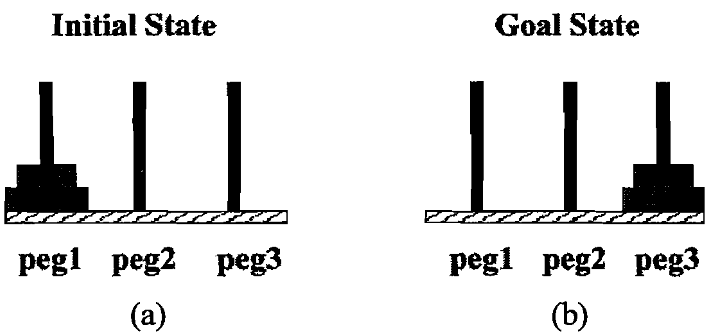

Figure 3

a) Write down the state representations of the initial and goal states. *(1 Mark)*
   You may use the following functions to represent the states and actions.
   On (<disc> <peg-x>): to mean <disc> is on <peg-x>.
   On (<disc-1>, <disc-2>): to mean <disc1> is on top of <disc-2>, which in turn is on the peg that <disc-2 > is on.
   Move (<disc>, <peg-x>, <peg-y>): to denote moving <disc> from <peg-x> to <peg-y>.

b) Write down the list of possible actions (in terms of actions, pre-conds, Add-list and Del-list). *(3 Mark)*

c) Detail the planning graph for this problem. *(4 Mark)*

d) From the planning graph, formulate the optimal plan to solve this problem. *(1 Mark)*

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