NATIONAL UNIVERSITY OF SINGAPORE
SCHOOL OF COMPUTING
EXAMINATION FOR
SEMESTER 1 AY2010/2011

CS3243: INTRODUCTION TO ARTIFICIAL INTELLIGENCE

23 November 2010 **Time Allowed: 2 Hours**

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains SIX (6) questions and comprises EIGHT (8) printed pages, including this page.
2. Answer **ALL** questions within the space provided in this booklet.
3. This is an OPEN BOOK examination.
4. Please write your Matriculation Number below.
5. Do not write your name.

MATRICULATION NO: _____

This portion is for examiner's use only

Question	Q1	Q2	Q3	Q4	Q5	Q6	Total
Max	**18**	**12**	**10**	**20**	**18**	**22**	100
Marks							

1. [18 marks] Consider Lagrange's four-square theorem, which states that any natural number can be represented as a sum of four squares, that is we can always find natural numbers A, B, C, and D such that:

$$N = A^2 + B^2 + C^2 + D^2$$

We will also assume that A, B, C, D, and E are positive integers and that $A \leq B \leq C \leq D$. Please note, as defined, variables may be bound to the same value.

a. (3 marks) Draw a constraint graph denoting the relations between the various variables.

b. (10 marks) Using forward checking and back-tracking, and trying domain values in increasing order (e.g., 1,2,3 ...), solve the problem by finding suitable values for each of the variables when N = 31. Assume forward checking halts the current search branch, if the sum exceeds 31.

c. (5 marks) Is the hill-climbing algorithm a suitable algorithm to use for this problem? Explain your answer.

2. [12 marks] Prisoner's Dilemma. Two suspects Penn and Teller are arrested by the police. The police have insufficient evidence for a total conviction, and separately offer the same deal. If one testifies for the prosecution against the other (*defects*) and the other remains silent (*cooperates*), the defector goes free and the silent accomplice receives a 10-year sentence. If both remain silent, both prisoners are sentenced to ½ year in jail for a minor charge. If each betrays the other, each receives a five-year sentence. Each prisoner must choose to betray the other or to remain silent. Each one is assured that the other would not know about the other's decision before the end of the investigation.

a. (7 marks) Use the minimax algorithm to help Penn decide if he should defect or cooperate. Draw the search tree and calculate Penn's action. Let the evaluation function be the number of years in prison that Penn has to endure.

b. (5 marks) Critique the use of the minimax algorithm to arrive at a decision for the prisoner's dilemma.

3. [10 marks] Prolog. Examine the following knowledge base in Prolog that is supposed to verify whether a 3-tuple is a subsequence of the Fibonacci number sequence.

```
p(0,1,1).
p(A,B,C) :- C =:= A+B, D is B-A, p(D,A,B).
```

To be clear, "=:=" is Prolog's equality operator, testing whether the left hand side argument has the same value as the right. The "`is`" operator assigns the left hand side variable to the (arithmetic) result on the right hand side.

Describe what the *first* result is for the following five queries given the knowledge base above (2 marks each). If any of the queries fail to give a result or never finish, state this.

A. `p(0,1,1).`

B. `p(1,1,2).`

C. `p(2,3,5).`

D. `p(5,12,30)`

E. `p(3,4,7)`

4. [20 marks] First Order Logic. Translate the following sentences into First Order Logic, restricting yourself to using the predicates *IsNew(x), IsOld(x), IsBlue(x), IsBorrowed(x,y,z), Mother(x,y), Marriageable(x), Possess(x,y)*

A. (3 marks) All old things are not new.

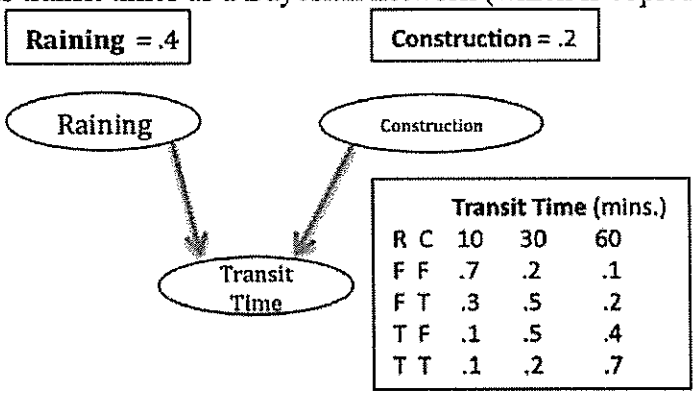
B. (3 marks) Blue things are borrowed from one's mother.

C. (3 marks) One must possess something old, something new, something borrowed and something blue to be marriageable.

D. (3 marks) In this KB, is it possible for an item to have both the properties of being new and old?

E. (8 marks) Lady Lovelace has (possesses) an old ring, a blue scarf borrowed from Pascale, and a new pair of earrings. Write these givens in First Order Logic, and then prove or disprove whether Lovelace is marriageable.

5. [18 marks] Uncertainty. Mr Chow Kway Teo (not his real name), an NUS student is about to leave his flat at Clementi and go to school. Kway Teo believes in probabilities and models his bus transit times as a Bayesian network (which is copied below).



A. (8 marks) If you can compute his expected transit time (assuming no other information), calculate it; if you cannot, state why not.

B. (4 marks) His mother, Xia Mien, SMSes him to tell him that it is raining outside and reminds him to bring an umbrella. If you can compute his expected transit time now, calculate it; if you cannot, state why not.

C. (4 marks) It actually takes Kway Teo 50 minutes to get to school. Calculate the probability that there was construction going on near the bus route; if you cannot, state why not.

D. (2 marks) Is it correct to say that Kway Teo's *unconditional* belief in getting to school via bus has changed with the addition of the information from his mother that it is raining?

6. [22 marks] Natural Language Processing

"Spam" is an English word that refers to both a specific brand of luncheon meat as well as unwanted (e)mail. The makers of Spam (the luncheon meat) have wanted to find comments about their product to see how to improve upon it, but many Web comments refer to email instead.

They have enlisted you to build a classifier that takes a sentence mentioning the word "spam" decide whether it is a sentence referring to their product or not. They have given you 10 labeled sentence fragments to start with, as shown below, where each sentence fragment is labeled as "+" (positive), if it was deemed to be about the luncheon meat.

MY YUMMY SPAM RECIPE, +	MY SPACE MY SPAM, -
KEEP SPAM OFF MY BLOG, -	COMMENTS DON'T SPAM, -
MY BLOG IS SPAM FREE, -	FREE SPAM RECIPE, +
SPAM FREE COMMENTS, -	MY BLOG SPAM RECIPE, +
SPAM RECIPE CONTEST, +	RECIPE IS SPAM, -

A. (9 marks) Create a decision tree model for this dataset, where a feature corresponds to the presence or absence of a word that occurs at least in two different messages. You may opt to only show relevant information gain work.

B. (4 marks) Show how the above classifier you created in Part A would classify the sentence fragment "SPAM IS YUMMY"

C. (4 marks) Show how the same Decision Tree classifier would classify the sentence "POWERED BY SPAM"

D. (5 marks) What problem would a Naïve Bayes classifier constructed from the above set encounter when predicting the class for the sentence "POWERED BY SPAM" in Part C? Briefly describe how could this problem be fixed.

= END OF PAPER =
(Goodbye, and good luck with the rest of your exams!)