THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

This exam paper must not be removed from the venue

Venue _____

Seat Number _____

Student Number |__|__|__|__|__|__|__|__|

Family Name _____

First Name _____

School of Information Technology and Electrical Engineering

EXAMINATION

Semester Two Final Examinations, 2015

COMP3702 Artificial Intelligence

This paper is for St Lucia Campus students.

Examination Duration: 120 minutes

Reading Time: 10 minutes

Number of Questions: 5 questions

Exam Conditions:

This is a Central Examination

This is a Closed Book Examination - no materials permitted

During reading time - write only on the rough paper provided

This examination paper will be released to the Library

Materials Permitted In The Exam Venue:

(No electronic aids are permitted e.g. laptops, phones)

Calculators - Casio FX82 series or UQ approved (labelled)

Materials To Be Supplied To Students:

1 x 14 Page Answer Booklet

Rough Paper

Instructions To Students:

Additional exam materials (eg. answer booklets, rough paper) will be provided upon request.

For Examiner Use Only

Question	Mark

Total _____

1. **[20 points]** Suppose we are given the following algorithm:

Algorithm 1 MysterySearch(graph G)

```
Initialize priority queue PQ with (G.initialState, 0, null) as the only element.
Initialize set E with an empty set
while PQ is not empty do
  n = PQ.deleteMin()
  if n.state == G.goalState then
    Return the solution
  for all s in successors(G, n.state) do
    g(s) = n.cost + G.weight(n.state, s)
    if s is not in PQ or E then
      PQ.insert(s, g(s), n.state)
    else
      PQ.checkDuplicate(s, g(s), n.state)
  E = E ∪ {n}
```

Each element of the priority queue is a 3-tuple (state S, cost C, parent P), where S is the state, C is the current minimum cost to reach state S from the initial state, and P is the predecessor of state S that results in the current minimum cost C. The function *checkDuplicate(s, g(s), s')* checks if the priority queue contains a node with state s. Suppose it does and the priority queue element is (s, C, P), then if $g(s) < C$, the element in the priority queue will be updated to $(s, g(s), s')$.

(a) **[5 points]** What search algorithm is MysterySearch?

(b) **[5 points]** Assuming the state and actions spaces of the search problem are finite, is MysterySearch complete? Please explain your answer.

(c) **[5 points]** Assuming the state and actions spaces of the search problem are finite, is MysterySearch optimal? Please explain your answer.

(d) **[5 points]** If there is no path between the initial and goal states in the input graph G, will MysterySearch halt? If it will, when?

2. **[20 points]** Suppose you are playing Cluedo and you have gathered the following information
Liars always speak what is false, and truth-tellers always speak what is true. Suppose Amy, Bob, and Cal are each either a liar or truth-teller. Amy says, Bob is a liar. Bob says, Cal is a liar. Cal says, Amy and Bob are liars.
The question is: Is Cal a liar? To answer this question, please:

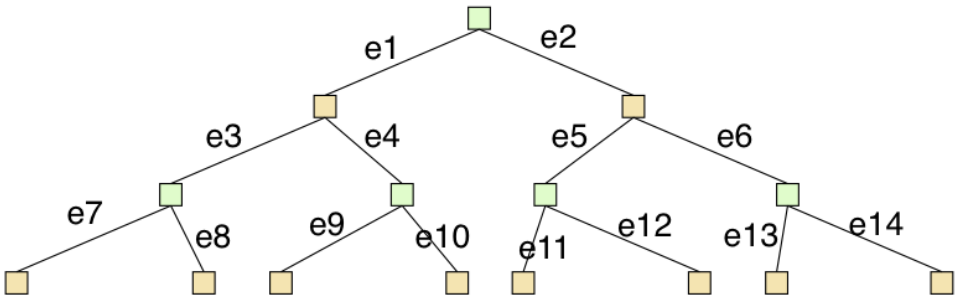
   (a) **[10 points]** Define the problem as a propositional logic problem. This means you need to define the atomic propositional logic sentences and decide the type of problem (i.e., validity or satisfiability).

   (b) **[10 points]** Please prove your answer using resolution refutation.

3. **[20 points]** Suppose you are playing a turn-taking, zero-sum game, where the opponent is a rational agent and you would like to use two-step lookahead to decide your move. You know that the complete min-max tree of the two-step lookahead strategy for this game will be a complete binary tree as shown in Figure 1 Suppose you are given access to a heuristic function that will give you a good estimate on the value of the leaf nodes of the complete tree (these estimated values are also written in Figure 1).

   (a) **[10 points]** Relying on the given heuristic, how should the tree be expanded if we want to maximize the benefit of $\alpha\beta$-pruning? Please write the answer as a sequence of edges to be visited.

   (b) **[10 points]** Please write a pseudo-code of the strategy you use to answer the previous question (i.e., 3.(a))



Estimated values of the leaf nodes from left to right: 2 ; 5 ; 1 ; 4 ; 6 ; 1 ; 3 ; 2

Figure 1: The complete min-max tree of the two-step lookahead strategy of the game.

4. **[20 points]** The toll roads provider in Brisbane, i.e., BrisToll, would like to attract more users by adjusting their pricing based on the amount of minutes users can save. As a trial run, BrisToll wants to apply this pricing approach to a new toll between Ipswich and Brisbane CBD. BrisToll notices that for this toll road, all of the target users are small business owners who are travelling to sell their products at a stall in King George Square between 10am and 3pm. Unfortunately, traffic congestions are common on the roads between Ipswich and Brisbane CBD, such that the sellers are often late in opening their stalls, and therefore reduce the amount of profit they could earn in a day. A simplified analysis on the relation between how late the owners come (grouped into the number of hours of being late) and the profit they earn are shown in the following table.

How late the owners are	How much profit they earn that day
On time	$400
Up to 1 hour (1 – 60 minutes)	$300
1 – 2 hours (61 – 120 minutes)	$200
3 – 4 hours (121 – 180 minutes)	$100

The analysis also reveals that without using the toll, the owners will not be late 40% of the time, late up to 1 hour 30% of the time, late between 1–2 hours 20% of the time, and late 3–4 hours 10% of the time. Furthermore, it can be assume that the amount of minutes the owner is late within each group are uniform. The uniform distribution within a group means that, for example, the probability the owner is 15 minutes late is the same as the probability that he/she is 30 minutes late, and the probability that the owner is late 70 minutes is the same as the probability that he/she is 80 minutes late, but the probability that the owner is 15 minutes late is different than the probability of being 80 minutes late.

Due to the advances in traffic monitoring, road users can know exactly the amount of minutes that the toll between Ipswich and Brisbane CBD will save them. Assuming the aforementioned information do not change when people's preference of using the toll change, and the fact that road users are rational agents who aim to maximize their earnings, please construct *a function that maps the amount of minutes the users (i.e., business owners) save by travelling through the toll to the maximum cost that BrisToll can set, so that the users are still attracted to use the toll road*. Please use the Maximum Expected Utility (from Decision Theory) to explain your answer.

5. **[20 points]** Dr. Y recently announced his new invention: A new update equation for solving MDP problems. The equation is called the Y update equation and is defined as follows:

$$Y_{i+1}(s) = \max_a \left(R(s,a) + \gamma \sum_{s'} T(s,a,s') \max_{a'} \left(R(s',a') + \gamma \sum_{s''} T(s',a',s'') Y_i(s'') \right) \right) \quad (1)$$

Dr. Y claimed that if we replace the Bellman update equation with the Y update equation, then the value iteration algorithm will converge to the optimal solution faster. To understand this new update equation better, please:

(a) **[10 points]** Find and explain the relation between the Y update equation and the Bellman update equation, if there is any relation. If there is no relation, please explain how you come to that conclusion.

(b) **[5 points]** Is Dr. Y's claim correct if "faster" is defined with respect to computation time? Please explain your answer.

(c) **[5 points]** Is Dr. Y's claim correct if "faster" is defined with respect to the number of iterations the value iteration takes to solve the MDP problems? Please explain your answer

End of Examination