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THE UNIVERSITY
of LIVERPOOL

SEPTEMBER 2002 EXAMINATIONS

Bachelor of Science: Year 2

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

TIME ALLOWED : Two Hours

INSTRUCTIONS TO CANDIDATES

SECTION A: Answer all 10 questions.

SECTION B: Credit will be given for the best 3 answers.

If you attempt to answer more questions than the required number of questions (in any section), the marks awarded for the excess questions will be discarded (starting with your lowest mark).

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Section A

Each question is worth 4 marks:

1. In the context of propositional logic, what is meant by a well-formed formula? For propositional logic, give examples of a well-formed formula and a formula that is not well-formed.

2. The $UnStack(x, y)$ action used in the STRIPS planner is given below.

	$UnStack(x, y)$
pre	$On(x, y) \wedge Clear(x) \wedge ArmEmpty$
del	$On(x, y) \wedge ArmEmpty$
add	$Holding(x) \wedge Clear(y)$

   In the blocks world with three blocks C, D, and E, explain how STRIPS would attempt to apply the action $UnStack(C, D)$ to the state

$$On(C, D) \wedge ArmEmpty \wedge OnTable(D) \wedge Clear(E) \wedge Clear(C) \wedge OnTable(E)$$

   showing the resultant state.

3. What is meant by the *thinking rationally* view of Artificial Intelligence?

4. Draw a truth table for the expression $(p \wedge \neg q) \Rightarrow (p \vee q)$.

5. In the context of a rule-based system, what is working memory?

6. Describe how to perform a depth-first search.

7. What is an *expert system shell*?

8. Using an example (in Prolog) explain what is meant in Prolog by *negation as failure*.

9. Write in first-order logic

   (a) Every dog has bitten a postman

   (b) Some dog has bitten every postman

10. In the context of search problems what is a heuristic and how are heuristics used?

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Section B

Answer 3 of the questions below. Each question is worth 20 marks.

1. Here is a simple puzzle.

   > A farmer has three dogs and 3 sheep that he wants to get across a river. He has a boat, which in addition to him, will hold one or two animals, but no more. If there are one or more sheep on a river bank, the farmer cannot leave more dogs than sheep on that river bank.

   Let (s, d, k) indicate that there are s sheep, d dogs, and k boats on the original side of the river. The initial state is $(3, 3, 1)$, goal state is $(0, 0, 0)$.

   (a) Give the operations that may be performed during the solution to the problem. **6 marks**

   (b) Write down the illegal states that result from the following statement in the problem. *If there are one or more sheep on a river bank, the farmer cannot leave more dogs than sheep on that river bank.* **3 marks**

   (c) Give a breadth first search to depth two for this problem. **7 marks**

   (d) Give one advantage and one disadvantage of breadth-first search as compared to depth-first search. **4 marks**

2. (a) A logic usually has a well defined *syntax*, *semantics* and *proof theory*. Explain what is meant by each of these. **6 marks**

   (b) Give an interpretation which satisfies the following formula of propositional logic.

   $$(p \vee q) \wedge (s \Rightarrow \neg r)$$

   Show how this formula is evaluated using your interpretation. **5 marks**

   (c) Briefly explain how the resolution proof method is carried out for deciding the validity of propositional logic formulae. **4 marks**

   (d) Using resolution show that $p \Rightarrow (q \Rightarrow p)$ is valid. **5 marks**

3. (a) Give four desirable features of a knowledge representation scheme, briefly describing each feature. **8 marks**

   (b) Describe the main features of a semantic network. **4 marks**

   (c) Show how the following statements can be encoded using a semantic network.

   ```
   Sean is tall.
   Sean gives Clare a book.
   ```

   4 marks

   (d) Give two disadvantages of semantic networks. **4 marks**

4. A small Prolog program is given below.

```
/****************************************
parent(X,Y) holds if X is the parent of Y
****************************************/

parent(christine,jonathan).
parent(christine,alison).
parent(christine,simon).
parent(peggy,christine).
parent(frank,christine).
parent(david,jonathan).
parent(david,simon).
parent(david,alison).

/*************************************************
predecessor(X,Y)

X is the predecessor of Y if X is the parent of Y, or
X is the parent of Z and Z is the predecessor of Y
*************************************************/

predecessor(X,Y):- parent(X,Y).
predecessor(X,Y):- parent(X,Z),predecessor(Z,Y).
```

(a) What does the query `parent(david,Y).` mean? Explain how Prolog answers the query, giving the output from Prolog if we keep asking for further solutions. Write a query to find all the parents of `jonathan`. **6 marks**

(b) Write a rule defining `grandparent(X,Y)` where a grandparent is the parent of a parent. **2 marks**

(c) Explain how Prolog answers the query `predecessor(frank,alison).` **4 marks**

(d) Explain the connection between Prolog and resolution. **3 marks**

(e) The predecessor rules can be written into first-order logic as the following two clauses.

$$predecessor(x, y) \vee \neg parent(x, y)$$
$$predecessor(x, y) \vee \neg parent(x, z) \vee \neg predecessor(z, y)$$

Show using resolution that the parent predicate (from the Prolog program), the predecessor rules written into first-order logic (above) and the clause $\neg predecessor(frank, alison)$ are unsatisfiable. **5 marks**