THE UNIVERSITY OF AUCKLAND

FIRST SEMESTER, 2006
Campus: City

COMPSCI.366

The Foundations of Artificial Intelligence

(Time allowed: 45 minutes)

This test is out of **100** marks.
Attempt **ALL** questions.
Write your answers in the space provided in this booklet. There is space at the back for answers that overflow the allotted space.
The use of calculators is **NOT** permitted.

Surname (Family Name):	
First Name(s):	
UoA ID Number:	
Login Name (UPI):	

Question	*Mark*	Marks Available
1		8
2		12
3		9
4		6
5		8
6		2
7		5
8		8
9		6
10		4
11		10
12		4
13		18
Total		100

Question 1

For each of the following English sentences, choose the first-order predicate calculus formula that best describes the sentence.
[8 marks]

There is a solution for every problem.

1. $\exists x \exists y$: $Problem(x) \wedge Solution(x,y)$
2. $\forall x \exists y$: $Problem(x) \wedge Solution(x,y)$
3. $\exists y \forall x$: $Problem(x) \wedge Solution(x,y)$
4. $\forall y \exists x$: $Problem(x) \wedge Solution(x,y)$
5. $\exists x \forall y$: $Problem(x) \wedge Solution(x,y)$
6. $\forall x \forall y$: $Problem(x) \wedge Solution(x,y)$

Only students who have answered all questions should leave the room.

1. $\forall x$: $Student(x) \wedge Questions\_answered(x) \rightarrow Leave\_room(x)$
2. $\forall x$: $Questions\_answered(x) \wedge Leave\_room(x) \rightarrow Student(x)$
3. $\forall x$: $Student(x) \wedge Leave\_room(x) \rightarrow Questions\_answered(x)$
4. $\forall x$: $Leave\_room(x) \rightarrow Student(x) \wedge Questions\_answered(x)$

Students like either coffee or tea.

1. $\forall x$: $Student(x) \rightarrow Likes\_coffee(x) \vee Likes\_tea(x)$
2. $\forall x$: $Likes\_coffee(x) \vee Likes\_tea(x) \rightarrow Student(x)$
3. $\forall x$: $[Student(x) \rightarrow Likes\_coffee(x)] \vee [Student(x) \rightarrow Likes\_tea(x)]$
4. $\forall x$: $Student(x) \rightarrow [Likes\_coffee(x) \wedge \neg Likes\_tea(x)] \vee [\neg Likes\_coffee(x) \wedge Likes\_tea(x)]$

Question 2

Unify the following sets of literals or indicate if this is not possible. P and Q are predicates, f and g are functions, a and b are constants, and x and z are variables.
[12 marks]

$\{P(x), Q(a)\}$

$\{P(x,y), P(a,x)\}$

$\{Q(a,y), Q(x,f(y))\}$

$\{P(f(g(y))), P(x)\}$

{Q(a), Q(g(y))}

{P(b,y), P(x,g(x))}

Question 3

Convert the following formulas into clause form.
[9 marks]

$\forall x \forall y \forall z$: $[P(x) \wedge Q(y)] \vee R(z)$

$\forall x \exists y \forall z$: $P(x) \wedge Q(y) \rightarrow R(z)$

$\exists x$: $P(x) \wedge [\exists y$: $Q(y)] \rightarrow [\exists y$: $R(y)]$

Question 4

Given the following set of propositional formulas, prove P by resolution.
[6 marks]

$$Q$$
$$T$$
$$P \lor R$$
$$\neg Q \lor S$$
$$\neg R \lor \neg S \lor T$$

Question 5

Given the standard min/max operations for fuzzy logic, compute the following fuzzy sets.
[8 marks]

$\tilde{A}$ = {(*a*, 0.5), (*b*, 0.7), (*c*, 0.4)}

Complement of $\tilde{A}$: $\tilde{A}^c$ =

$\tilde{A}_1$ = {(*a*, 0.4), (*b*, 0.6), (*c*, 0.3)} $\tilde{A}_2$ = {(*a*, 0.8), (*b*, 0.2), (*c*, 0.5)}

Intersection of $\tilde{A}_1$ and $\tilde{A}_2$: $\tilde{A}_1 \cap \tilde{A}_2$ =

$\tilde{A}_1$ = {(*a*, 0.1), (*b*, 0.9), (*c*, 0.7)} $\tilde{A}_2$ = {(*a*, 0.4), (*b*, 0.5), (*c*, 0.8)}

Union of $\tilde{A}_1$ and $\tilde{A}_2$: $\tilde{A}_1 \cup \tilde{A}_2$ =

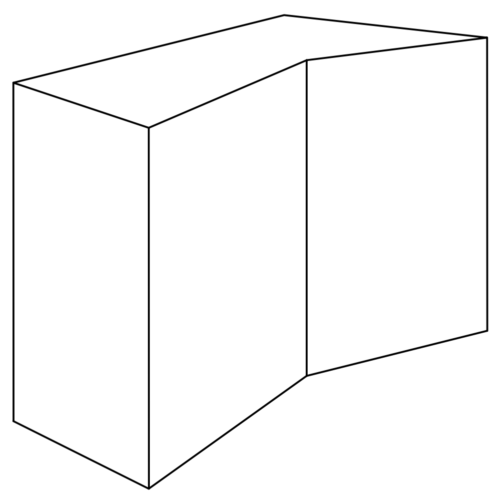
Question 6

Compute the 0.5-level set of the fuzzy set $\tilde{A} = \{(a, 0.3), (b, 0.7), (c, 0.4), (d, 0.8)\}$.
[2 marks]

$A_{0.5}$ =

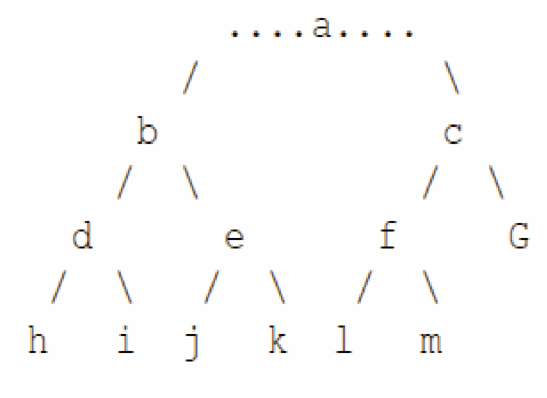
Question 7

Show one consistent labelling for the following polyhedron drawing (as it could have resulted from Waltz filtering). Use the label + for convex lines, – for concave line, and < for boundary lines.
[5 marks]



Question 8

In the search tree below, the G node is a goal node, the rest of the nodes are not goal nodes.
(1) How many nodes would be created by the breadth-first search algorithm?
(2) How many nodes would be created by the iterative-deepening search algorithm?
(3) List the nodes created by the breadth-first algorithm in their order of creation.
(4) List the nodes created by the iterative-deepening algorithm in their order of creation.
[8 marks]



1. 13 nodes (or 7 if search stops at G)

2. 11 nodes.

3. a b c d e f G (h i j k l m)

4. a | a b c | a b d e c f G.

Question 9

1) What is the difference between a *genetic algorithm* and a *random search algorithm*?
[2 marks]

A GA is only partly random, mutation is usually low <5% and selection of the fittest has a random component. A random search algorithm is 100% random.

2) What is the difference between a *genetic algorithm* and a *greedy hill-climbing algorithm*?
[2 marks]

A hill climbing algorithm can get trapped in local maxima, whereas random mutations can allow a GA to escape being trapped.

3) Genetic algorithms can be seen as a combination of *local* and *global* search. If so, which of cross-over and mutations provides the local search and which the global one?
[2 marks]

Cross over = local search

Mutation = global search

Question 10

What is the common characteristic of all *stochastic search* algorithms? Describe in a short sentence.
[4 marks]

They all use some (usually a small %) random search element.

Question 11

1) List 2 behaviours that multi-agent systems should exhibit?
[2 marks]

Any of:
cooperation, coordination, communication, negotiation, independence, autonomous action……etc

2) For the following games decide if they are mostly *deterministic* or *non-deterministic*.
[4 marks]

Checkers………deterministic

Rugby…………non- deterministic

Chess…………. Deterministic

Quake…………non-deterministic (definitely in multi-player and probably vs. computer as well)

3) For the following games decided if the are mostly *discrete* or *continuous*.
[4 marks]

Checkers………discrete

Rugby…………continuous

Chess………….discrete

Quake…………continuous

Question 12

Briefly describe the difference between a *first-order intentional system* and a *second-order intentional system*.
[2 marks]

A 1st order system has beliefs and intentions a 2nd order system has beliefs about beliefs and intentiions

2) Why is it useful to describe multi-agent systems as having intentional notions?
[2 marks]

Intentional notions provide abstraction – we can reason/program at a more abstract level.

Question 13

Define the *facts* for the following STRIPS *actions.*

1) stack(x,y)
[3 marks]

name *Stack(x, y)*

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

2) unstack(x,y)
[3 marks]

name *UnStack(x, y)*

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

3) pickup(x)
[3 marks]

name *PickUp(x)*

pre	***Clear(x)*** $\wedge$ ***OnTable(x)*** $\wedge$ ***ArmEmpty***
del	***OnTable(x)*** $\wedge$ ***ArmEmpty***
add	***Holding(x)***

4) putdown(x)
[3 marks]

name *PutDown(x)*

pre	***Holding(x)***
del	***Holding(x)***
add	***Clear(x)*** $\wedge$ ***OnTable(x)*** $\wedge$ ***ArmEmpty***

5) If the current world state can be described by the following STRIPS *facts*.

clear(A)
on(A,B)
onTable(B)
onTable(C)
armEmpty

Describe the world state after the following sequence of STRIPS *actions*

unStack(A,B)
Stack(B,C)
pickUp(B)
Stack(A,C)

[6 marks]

clear(A)
on(A,C)
onTable(B)
onTable(C)
armEmpty

This assumes that in order to complete Stack(A,C) B must be put down, STRIPS will do this if the precondition of an action is not met it will see if any action will enable the preconditions to be met.