Family Name:	
Other Names:	
Signature:	
Student Number:	

This PAPER is NOT to be retained by the STUDENT

The University Of New South Wales

C0MP4418 Practice Exam (Not Marked!)

Knowledge Representation and Reasoning

October 2017

Time allowed: **2 Hours plus 10 Minutes reading time**
Total number of questions: **27**
Total number of marks: **100**

Questions in PART A, must be answered on the generalised answer sheet provided.
Questions in PART B, PART C and PART D must be answered in the answer book(s) provided.
You must hand in this entire exam paper and ALL your answer booklets. Otherwise you will get zero marks for the exam and a possible charge of academic misconduct.
Ensure that you fill in all of the details on the front of this pink paper, generalised answer sheet, and answer booklet(s) and then SIGN everything. This exam paper is printed single-sided so that you can use the reverse side of each page for working. You must hand this paper back with your generalised answer sheet and answer booklets at the conclusion of the exam.

Do not use red pen or pencil in the answer booklets for this exam.

No examination materials permitted.
Calculators may **not** be used.
Questions are **not** worth equal marks.
Answer **all** questions.

Part A: Multiple Choice Questions

NOTE: Answer the questions in this section on the generalised answer sheet provided.

Note that each question has *five* alternatives. Once you have chosen an alternative, fill in the multiple-choice answer sheet by giving the letter (in square brackets e.g., "[B]") which corresponds to that alternative. Also, be careful that you fill each answer in on the correct row on the multiple-choice sheet (i.e., the row corresponding to the question number).

Each question in this section is worth **2 marks**. There is a **penalty** of $-\frac{1}{2}$ **mark** for answering a question in this section incorrectly. There is no penalty for not answering a question. In other words, you get no marks for a question if you do not attempt it and you lose half a mark for getting a question wrong.

DO NOT answer these questions in an **answer booklet** or this **question paper**!

Question 1

Which of the following propositional formulas is a tautology?

[A] $p \to (q \to p)$.
[B] p.
[C] $p \vee p$
[D] $(p \to q) \wedge (q \to p)$.
[E] $\neg\neg p$.

Question 2

How many positive literals can appear in a definite clause?

[A] At most one.
[B] At least one.
[C] At least one but no more than three.
[D] Exactly one.
[E] Zero or more.

Question 3

SLD resolution is most appropriate when the knowledge base consists entirely of?

[A] Arbitrary formulas.
[B] Arbitrary clauses.
[C] Horn clauses.
[D] Negative clauses.
[E] None of the above.

Question 4

Which of the following formal approaches to reasoning tries to capture commonsense reasoning?

[A] Default logic.
[B] First-order logic.
[C] Propositional logic.
[D] Resolution.
[E] None of the above.

Question 5

In Prolog, rules correspond to which type of formulas? Give the most approporiate answer.

[A] Arbitrary formulas.
[B] Arbitrary clauses.
[C] Definite clauses.
[D] Facts.
[E] Horn clauses.

Question 6

In first-order logic, how would you express that "something likes something"?

[A] $\exists x \exists y Likes(x, y)$
[B] $\exists x \forall y Likes(x, y)$
[C] $\forall x \exists y Likes(x, y)$
[D] $\forall x \forall y Likes(x, y)$
[E] None of the above.

Question 7

Which of the following is not required to convert a formual into conjunctive normal form?

[A] Drop universal quantifiers.
[B] Eliminate implication.
[C] Resolve two clauses with complementary literals.
[D] Skolemisation.
[E] Standardise variables.

Question 8

What is the idea behind Conflict-Driven Clause Learning?

[A] Add unit clauses to shrink subtrees.
[B] Add conflict clauses to generate new subtrees.
[C] Add unit clauses to generate an assignment
[D] Add conflict clauses to prune subtrees.
[E] Add clauses based on conflict resolution.

Question 9

Which of the following is **not** a source of relevant complexity in logical reasoning?

[A] Knowledge is closed under subsumption.
[B] All tautologies are known.
[C] Knowledge is closed under logical consequence
[D] Knowledge is closed under equivalence.
[E] Inconsistent knowledge implies knowing everything.

Question 10

Which of the following is true in our first approach to limited belief?

[A] $e, v \models_{\mathrm{T}} \alpha \iff e, v \not\models_{\mathrm{T}} \alpha$
[B] $e, v \models_{\mathrm{F}} \alpha \iff e, v \not\models_{\mathrm{F}} \alpha$
[C] $e, v \models_{\mathrm{T}} (\alpha \vee \beta) \iff e, v \models_{\mathrm{T}} \alpha$ and $e, v \models_{\mathrm{T}} \beta$
[D] $e, v \models_{\mathrm{F}} (\alpha \vee \beta) \iff e, v \models_{\mathrm{T}} \alpha$ and $e, v \models_{\mathrm{T}} \beta$
[E] $e, v \models_{\mathrm{F}} (\alpha \vee \beta) \iff e, v \models_{\mathrm{F}} \alpha$ and $e, v \models_{\mathrm{F}} \beta$

Question 11

Suppose $e, w, z \models \mathrm{SF}(n) \wedge \mathbf{K}(\mathrm{SF}(n) \to [n]\mathrm{SF}(n))$. Which of the following follows?

[A] $e, w, z \models \mathbf{K}[n]\mathrm{SF}(n)$
[B] $e, w, z \models [n]\mathbf{K}\mathrm{SF}(n)$
[C] $e, w, z \models \neg\mathbf{K}\mathrm{SF}(n)$
[D] $e, w, z \models \neg[n]\mathbf{K}\mathrm{SF}(n)$
[E] $e, w, z \models \neg\mathbf{K}\neg[n]\mathrm{SF}(n)$

Question 12

Suppose all you know is the following KB:

$$P(\#1) \wedge P(\#2) \wedge$$
$$Q(\#2) \wedge Q(\#3) \wedge$$
$$\big(R(x,y) \leftrightarrow (P(x) \wedge Q(x)) \wedge (P(y) \vee Q(y))\big)$$

What are the known instances (x, y) of the R, i.e., for which (x, y) does $\mathbf{O}\text{KB} \models \mathbf{K}R(x, y)$ hold?

[A] $\{\#1, \#2, \#3\} \times \{\#1, \#2, \#3\}$
[B] $\{(\#2, \#1), (\#2, \#2), (\#2, \#3)\}$
[C] $\{\}$
[D] $\{\#2\} \times \{\#1, \#2, \#3, \ldots\}$
[E] $\{(\#2, \#2)\}$

Question 13

Which of the following sentences is valid in the logic $\mathcal{OL}$?

[A] $\neg\mathbf{K}\alpha \rightarrow \mathbf{K}\neg\mathbf{K}\alpha$
[B] $\mathbf{K}\alpha \vee \mathbf{K}\neg\alpha$
[C] $\neg\mathbf{K}\alpha \rightarrow \mathbf{K}\neg\alpha$
[D] $\mathbf{K}\alpha \rightarrow \neg\mathbf{K}\neg\alpha$
[E] $\neg(\mathbf{K}\alpha \wedge \mathbf{K}\neg\alpha)$

Question 14

What does the frame problem refer to?

[A] Representing the positive effects of actions.
[B] Representing the negative effects of actions.
[C] Representing what is not changed by actions.
[D] Representing the minor preconditions of an action.
[E] Representing the indirect effects of an action.

Question 15

Which domain would be easiest to encode in a classical planning language (e.g., STRIPS)?

[A] Monopoly.
[B] Monty Hall Problem.
[C] 15-puzzle.
[D] Graph Colouring.
[E] None of the above.

Question 16

What is the most appropriate formal model to represent the game of tic-tac-toe?

[A] Markov chain (Markov Process).
[B] Markov Decision Process (MDP).
[C] Hidden Markov model (HMM).
[D] Partially-observable Markov decision process (POMDP).
[E] None/Other.

Question 17

In the game theory problem of the Prisoner's Dilemma, what is the Nash Equilibria

[A] A mixed Nash Equilibria of each player choosing to defect with probability 1/2.
[B] A pure Nash Equilibria of both players co-operating.
[C] A pure Nash Equilibria of both players defecting.
[D] A pure Nash Equilibria of one player defecting and the other co-operating.
[E] There is no Nash Equilibria.

Question 18

Consider the following profile with 10 voters and 3 candidates. E.g., there are 4 voters with preference A $\succ$ B $\succ$ C.

4	3	3
A	B	C
B	C	A
C	A	B

What are the Borda scores for each candidate?

[A] A:10, B:11, C:7.
[B] A:10, B:8, C:7.
[C] A:11, B:9, C:8.
[D] A:11, B:10, C:9.
[E] None of the above.

Part B: Introduction to KRR, Formal Logic and Reasoning

NOTE: Answer the questions in this section in the answer book provided.

Make your answers as clear and easy to understand as possible. Confusing or illegible solutions will lose marks.

Question 19

(8 marks)

Determine whether the following hold:

- $p \rightarrow q, q \rightarrow r \vdash p \rightarrow r$
- $p \rightarrow q \models \neg q \rightarrow \neg p$
- $\models p \leftrightarrow \neg\neg p$
- $p \vee \neg p \vdash$

Question 20

(6 marks)

Consider the following three sentences:

[A] All birds except emu's fly

[B] Tweety is a bird that doesn't fly

Write a formula in first-order logic expressing each of the given facts. Call them A and B. Show semantically whether these two formulas are sufficient to determine whether Tweety is an emu or not.

Question 21

(6 marks)

Determine whether the following is a valid inference in first-order logic using resolution:
$\forall x.(P(x) \to Q(x)), \forall x.(\neg R(x) \to \neg Q(x)) \vdash \forall x.(\neg R(x) \to \neg P(x))$

Part C: Non-Monotonic Reasoning, Reasoning About Knowledge, Reasoning About Actions

NOTE: Answer the questions in this section in the answer book provided.

Make your answers as clear and easy to understand as possible. Confusing or illegible solutions will lose marks.

Question 22

(10 marks)

Let α denote $(a \vee b \vee c) \wedge (\neg a \vee b \vee c)$.

[A] Prove semantically that the entailment $\mathbf{O}\alpha \models \mathbf{K}(b \vee c) \wedge \neg\mathbf{K}\neg b$ holds in the logic of knowledge. (E.g., "Let $e, w \models \mathbf{O}\alpha$. Then $e, w \models \mathbf{K}(b \vee c) \wedge \neg\mathbf{K}b$ iff ...")

[B] Explain informally for which $k \geq 0$ and $k' \geq 0$ the entailment $\mathbf{O}\alpha \mid\!\approx \mathbf{K}_k(b \vee c) \wedge \mathbf{M}_{k'}b$ holds in the logic of limited belief.

Part D: Planning and Decision Making

NOTE: Answer the questions in this section in the file answer book provided.

Make your answers as clear and easy to understand as possible. Confusing or illegible solutions will lose marks. Provide justifications where needed but irrelevant text detracting from the answer will lose marks.

Question 23

(10 marks)

Consider the following STRIPS planning problem.

- List the fixed relations and the dynamic relations.
- How many different states are there in the state space?
- Provide a plan to reach the goal from the initial state.

Init (On(A, B) $\wedge$ On(B, C) $\wedge$ On(C, D) $\wedge$ Table(D) $\wedge$ Clear(A) $\wedge$ HandEmpty)

Goal (table(A), $\wedge$ On(B,A) $\wedge$ On(C,B) $\wedge$ holding(D))

Action(Unstack(x, y),
PRECOND: HandEmpty $\wedge$ Clear(x) $\wedge$ On(x,y)
EFFECT: $\neg$HandEmpty $\wedge$ Holding(x), $\neg$Clear(x) $\wedge$ $\neg$On(x,y) $\wedge$ Clear(y))

Action(Stack(x, y),
PRECOND: Holding(x) $\wedge$ Clear(y)
EFFECT: $\wedge$ $\neg$Holding(x) $\wedge$ HandEmpty $\wedge$ On(x,y) $\wedge$ Clear(x) $\wedge$ $\neg$Clear(y))

Action(Pickup(x),
PRECOND: HandEmpty $\wedge$ Table(x) $\wedge$ Clear(x)
EFFECT: $\neg$HandEmpty $\wedge$ Holding(x), $\neg$Clear(x) $\wedge$ $\wedge$ $\neg$Clear(x) $\wedge$ $\neg$Table(x))

Action(Putdown(x),
PRECOND: Holding(x)
EFFECT: $\neg$Holding(x) $\wedge$ HandEmpty $\wedge$ Clear(x) $\wedge$ Table(x))