THE UNIVERSITY OF AUCKLAND

FIRST SEMESTER, 2002
Campus: City

COMPUTER SCIENCE

Foundations of Artificial Intelligence

(Time allowed: TWO hours)

NOTE: Attempt all questions.
Put the answers in the boxes below the questions.

MARKS	
SECTION A:	(out of 16)
SECTION B:	(out of 12)
SECTION C:	(out of 3)
SECTION D:	(out of 10)
SECTION E:	(out of 20)
SECTION F:	(out of 12)
SECTION G:	(out of 6)
SECTION H:	(out of 6)
SECTION I:	(out of 13)
TOTAL	**(out of 100)**

SURNAME:

FORENAME(S):

STUDENT ID:

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Section A: Search

1. Bidirectional search aims at improving the search for a path from the start node to the goal node by searching simultaneously from the start to the goal and the goal from the start. Briefly explain what could happen that makes this type of search even less efficient than unidirectional search. [3 marks]

2. A variant of the standard hill-climbing procedure keeps a set of the best n nodes in memory, rather than just the one best node so far. Briefly discuss the advantage of this approach. [3 marks]

3. The probability with which a worse node is excepted during simulated annealing decreases over time. What would happen if the probability is kept constant? [3 marks]

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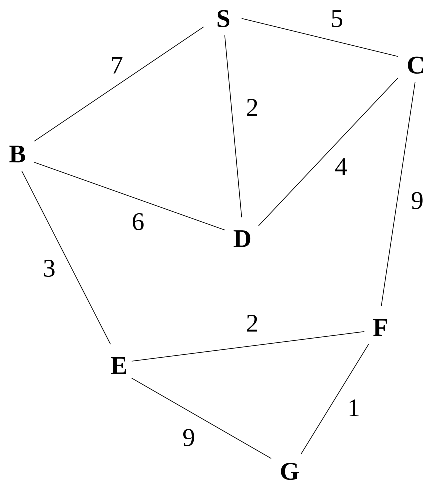
4. Consider the following search graph to be used for a uniform cost search from **S** to **G** (i.e., a best-first search which uses as evaluation function the cost of the path from **S** to the current node). The edges of the graph are annotated with the costs of the individual steps between the nodes. The answer box contains the start of a trace showing which nodes are currently considered by the search algorithm (in increasing order of their cost). Complete the trace until it contains only the goal node.



[7 marks]

(1) **S**/0

(2) **D**/2, **C**/5, **B**/7

(3) **C**/5, **B**/7

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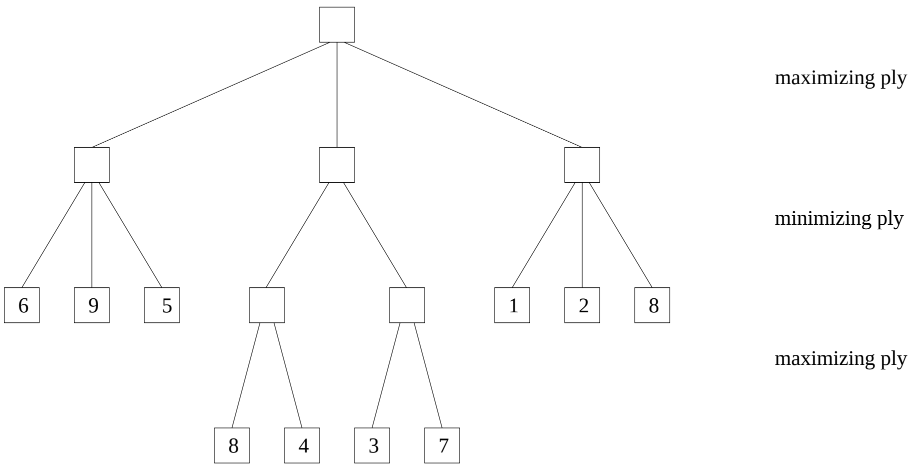
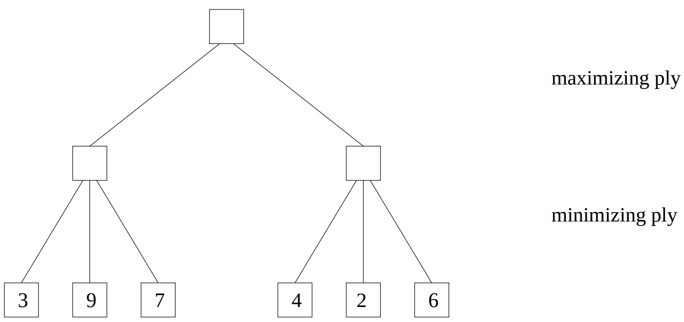
Section B: Games

5. The minimax procedure expands nodes in a game search tree to a given depth d before assigning values to the nodes. What would be the maximal depth of nodes in the same tree when alpha-beta pruning is used in the minimax procedure. [2 marks]

6. In the following game search tree, fill in the blank boxes with the appropriate numbers. [6 marks]



7. In the following game tree, cross out all nodes that are cut off during alpha-beta search (assuming node expansion from left to right). [4 marks]



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Section C: Prolog

8. *Accumulator Pairs*

   You are to write the code for the predicates reverse/2 and reverse/3 (i.e., reverse with 2 arguments and reverse with 3 arguments), where reverse(X,Y) is true if X and Y are both lists and X unifies with the top-level reversal of Y. For example, reverse([1, [2, 3], 4], [4, [2, 3], 1]) is true. In writing the code for reverse/2 and reverse/3 you are (obviously) allowed to freely use Prolog's list notation, HOWEVER you are NOT allowed to use any other predicates than what is specified in the following: (1) reverse/2 only calls reverse/3.
   (2) reverse/3 is a "helper" predicate which uses an accumulator pair to actually reverse the list.
   and (3) reverse/3 only calls itself. [5 marks]

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Section D: POP Planning: Handling Threats

Plans and operators are represented here just as they were for assignment 2 and in the test. Partially-ordered plans are: plan(Steps, CausalLinks, Orderings). Assume you were given the following operator schemas:

```
op1:params=[A,B]    op2:params=[A,B]
    preconds=[]         preconds=[m(A,B)]
    effects=[m(A,B)]    effects=[n(A,B)]

op3:params=[A,B]         op4:params=[A,B]
    preconds=[]              preconds=[not(m(A,B))]
    effects=[not(m(A,B))]    effects=[q(B,A)]
```

The following are partial plan structures with all information involving the start and finish pseudo-steps omitted.

9. You are given the following partial plan structure:

```
plan(steps([step(p,op1,[a,b]),step(c,op2,[a,b]),
            step(s1,op3,[c,d]),step(s2,op3,[a,b])]),
     causalLinks([causalLink(p,m(a,b),c)]),
     orderings([isBefore(p,c), isBefore(s1,c),
                isBefore(s2,s1)])).
```

There is a threaten causal link in this partial plan structure. What do you add to this partial plan structure to resolve the threat? Give the new partial plan structure with the threat resolved. [6 marks]

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10. You are given the following partial plan structure:

```
plan(steps([step(p,op1,[a,b]),step(c,op2,[a,b]),
            step(s1,op3,[X,b])]),
     causalLinks([causalLink(p,m(a,b),c)]),
     orderings([isBefore(p,c), isBefore(s1,c),
                isBefore(p,s1)]))
```

(a) There is a threaten causal link in this partial plan structure. What is the threat? Specifically, what step threatens the causal link and how? [1 mark]

(b) Our current plan structure does not allow us to resolve this threat in a least-commitment way (i.e., in a way analogous to the way that step ordering commitments can be constrained by using explicit step order constraints). Extend the plan structure to enable the planner to resolve the current threat without overcommitting the planner. The current plan structure has 3 components: list of steps, list of causal links, and list of step order constraints. What new component could we add to the plan structure (so that a plan would then have 4 components)? [Hint: Our blocksWorld operator schemas use something similar to prevent impossible moves.] Show what the partial plan structure would look like after the threat has been resolved using the new plan structure. [3 marks]

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Section E: Logic

11. Write the following English sentences as predicate calculus formulas, using the predicates Likes(x,y), Student(x), and Equals(x,y), Programs(x,y). [3 marks]

    (a) When a student likes webdesign then they will program in C.

    (b) Whenever a student likes databases or likes operating systems, then the student programs in Fortran and Java.

    (c) Whenever a student only likes AI, then there exists a student who only programs in Perl

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12. Unify the following sets of axioms if possible. a and b are literials and x,y,z are variables. [2 marks]

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

    (b) $\{R(a, y), R(x, f(y))\}$

    (c) $\{R(f(g(z))), S(x)\}$

    (d) $\{S(b), S(f(x))\}$

    (e) $\{R(y, f(y)), R(a, x)\}$

13. Why is resolution semi-decidable? [2 marks]

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14. Put the following statements into clausal form. [3 marks]

(a) $\exists x \forall y \exists u : (S(x) \rightarrow [T(y) \land P(u)])$

(b) $\forall u \forall y : ([T(u) \lor P(y)] \rightarrow \exists x : S(x, y, u))$

(c) $\forall x\{T(x) \rightarrow \exists y\{S(x, y)\}\} \land \forall x\{\neg T(x) \rightarrow \neg \exists y\{P(y, x)\}\}$

15. Can you show for each of the two formulas listed below that it is logically implied by the other axioms using resolution? If so do so, otherwise explain why you cannot. [10 marks]

$\neg crulytail(x) \lor \neg bushytail(x) \lor faster(x, y)$
$\neg paws(x) \lor \neg hoofs(y) \lor faster(x, y)$
$\neg fox(x) \lor paws(x)$
$\neg pig(x) \lor hoof(x)$
$\neg fox(x) \lor bushytail(x)$
$\neg pig(x) \lor curlytail(x)$
$bushytail(Joe)$
$pig(Pat)$
$fox(Hans)$

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(a) faster(Hans,Pat)

Surname: ______________________________

Forename(s): ______________________________

(b) fast(Joe,Pat)

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Section F: Natural Language

16. Given the following English grammar:

Terminals: {MANY, PEOPLE, WERE, ANGERED, BY, THE, HEARINGS}

Nonterminals: $\{S, NP, VP, PP, D, N, V, AV\}$

Start symbol: S

Productions:

$S \rightarrow NP\ VP$	$N \rightarrow$ PEOPLE
$NP \rightarrow D\ N$	$N \rightarrow$ HEARINGS
$NP \rightarrow AV\ N$	$V \rightarrow$ WERE
$VP \rightarrow V\ AV$	$AV \rightarrow$ ANGERED
$VP \rightarrow V\ PP$	$D \rightarrow$ THE
$VP \rightarrow VP\ PP$	$AV \rightarrow$ MANY
$VP \rightarrow P\ AV$	$P \rightarrow$ BY
$PP \rightarrow P\ NP$	

Show the parse tree for each of the following sentences that is grammatically correct. Otherwise, briefly explain why there exist no parse tree for the sentence. [5 marks]

(a) MANY PEOPLE WERE ANGERED BY THE HEARINGS.

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(b) MANY WERE ANGERED BY THE MANY HEARINGS.

17. A robust parser should return the correct or a useful close analysis for 90% or more of input sentences. Please describe at least three problems that it would need to solve, which create severe difficulties for conventional parsers utilising standard parsing algorithms with a generative grammar. [3 marks]

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18. What is shallow parsing? [2 marks]

19. Describe when shallow parsing can be used in order to improve the results of a parsing process. [2 marks]

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Section G: ISA Hierarchies

20. What would be the answers to the following queries based on the following isa hierarchy (remember about inheritance and default reasoning). [4 marks]

    (John is a man)
    (a man has a car)
    (a car is a toy)
    (John is an acrobat)
    (an acrobat has a joggling ball)
    (a joggling ball is easy-to-handle)

    (a) (John has a toy)

    (b) (John is easy-to-handle)

21. Given the following inheritance rule for ISA and HAS, please give an example to illustrate the inheritance. [2 marks]

    If X isa Y and Z has X then Z has Y.

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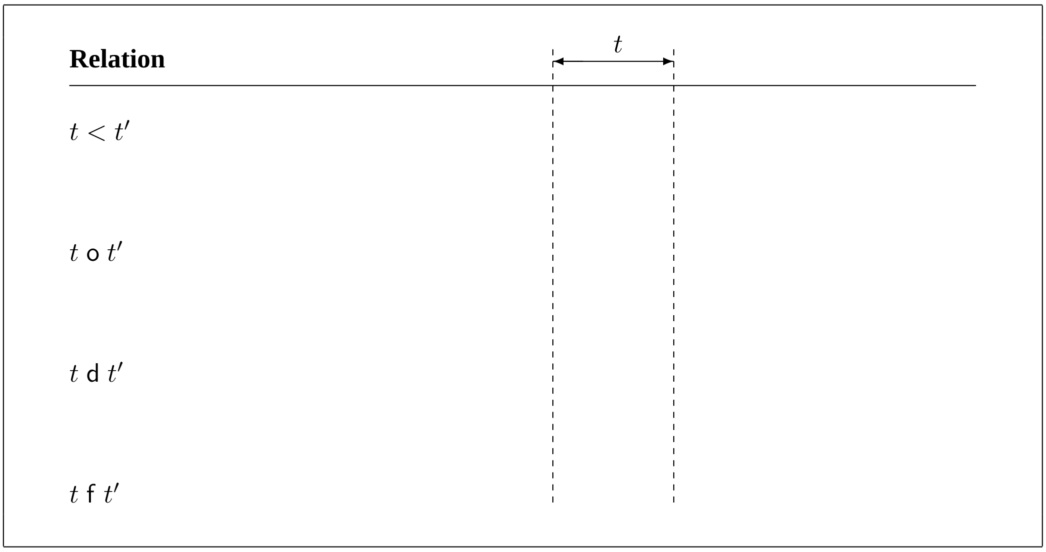
Section H: Temporal Reasoning

22. Indicate in the diagram the temporal extents of time intervals t' that are in the specified relations to the given time interval t. [3 marks]



23. Using the abbreviations $=, <, >$, m, mi, o, oi, d, di, s, si, f, fi for relations between time intervals, specify the composite relations between the respective time intervals as given in the following statements:

    (a) a ends before b ends. [1 mark]

    (b) k starts during l. [2 marks]

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Section I: Reasoning under Uncertainty

24. Fill in the missing numbers in the following table: [5 marks]

Expression	*Probabilistic logic*	*Possibilistic logic*
A	0.1	0.1
B	0.4	0.4
$\neg A$		
$A \wedge B$		
$A \vee B$		
$A \rightarrow B$		

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25. Suppose the following statements and probabilities are given:

    (a) There will be a storm tomorrow ($p = 0.1$).
    (b) The temperature tomorrow will be below $15°$ C ($p = 0.5$).
    (c) I am going surfing tomorrow. ($p = 0.25$).

    Determine the probability of the following statements using possibilistic logic rules. [6 marks]

There will be no storm tomorrow.	
Tomorrow there will be a storm and the temperature will be below $15°$ C.	
If there is no storm tomorrow, I am going surfing tomorrow.	

26. If there is a 90% chance of a screening test to detect breast cancer, what are the odds that a screening test detects breast cancer? [2 marks]