The University of British Columbia
Department of Computer Science
Midterm Examination 3 — Fall 2019

Computer Science 312
Functional and Logic Programming

Question 1 [12 marks]

(a) [4 marks] What does "g is not a logical consequence of KB" mean? [Copying the defintion of logical consequnce from you notes and putting "not" in the front will not result in many marks.]

(b) [6 marks] Consider the following (partial) derivation of the query ?w. Note that the knowledge base is not specified. Fill in the underlined missing answers.

Answer clause	Clause resolved
`yes :- w`	
	`w :- x, y.`
`yes :- x, y`	
	(a) ____________________
`yes :- u, v, y`	
	`u :- s.`
`yes :- s, v, y`	
	(b) ____________________
`yes :- v, y`	
	`v :- y.`
(c) ____________________	
	`y :- t.`
`yes :- t, y`	

(c) [2 marks] If the proof fails here, what can you say about the knowledge base?

Question 2 [10 marks]

Consider the following logic program (assume there are declatations so there are no undefined predicate errors):

```
a :- b,c,d.
a :- e.
b :- g.
b :- m.
g.
c :- m.
e :- g.
d.
```

(a) [5 marks] Draw the box model for a. You need to include the ports (boxes and lines/arrrows), but not the port names. You need to include the names for the atoms that the boxes represent.

(b) [5 marks] Here is a (edited) trace of the query `?- a.` Fill in the missing (underlined) lines:

```
[trace]  ?- a.
   Call: a
   Call: b

   ---------------------------------------
   Exit: g

   ---------------------------------------
   Call: c
   Call: m
   Fail: m

   ---------------------------------------
   Redo: b
   Call: m
   Fail: m
   Fail: b

   ---------------------------------------
   Call: e
   Call: g
   Exit: g

   ---------------------------------------
   Exit: a
true.
```

Question 3 [10 marks]

A binary search tree is a useful definition of a set. Suppose a set in Prolog is defined by the constant *empty*, denoting the empty set, and the term $\mathit{set}(E, \mathit{LS}, \mathit{RS})$ which denotes the set where E is an element of the set, LS is the set containing the elements less than E and RS is the set of elements greater than E.

The set $\{2, 7, 9, 11\}$ can thus be represented as

$$\mathit{set}(7, \mathit{set}(2, \mathit{empty}, \mathit{empty}), \mathit{set}(9, \mathit{empty}, \mathit{set}(11, \mathit{empty}, \mathit{empty})))$$

Consider the following Prolog code:

```
elem(E, set(E,_,_)).
elem(V, set(E,LT,_)) :-
    V #< E,
    elem(V,LT).
elem(V, set(E,_,RT)) :-
    E #< V,
    elem(V,RT).
```

where `#<` is an infix binary predicate between integers representing “less than”.

(a) [3 marks] What is the first result of the following query?

```
?- elem(3,S),elem(8,S).
```

(b) [7 marks] Implement the following relation in Prolog:
(The only predicate you can use that you do not define is `#<`.)

```
% insert(E,S,S1) is true if S1 is a set containing E and the elements of set S
```

Question 4 [10 marks]

In assignment 1, we wrote a program where the solution was:

```
-- myapply lst sub where sub is a list of (x,y) pairs, replaces each occurrence of x by y in lst.
myapply :: Eq t => [t] -> [(t, t)] -> [t]
myapply []  _ = []
myapply (h:t) sub = app h sub : myapply t sub
    where
       -- app e sub gives the value e is replaced by according to sub
       app e [] = e
       app e ((x,y):r)
           | e==x = y
           | otherwise = app e r
```

The analogous Prolog program *myapply*(*Lst*, *Sub*, *Res*) is true when *Lst* is a list, *Sub* is a list of (X, Y) pairs, and *Res* is the result of replacing each X by Y in *Lst*. It should have the following behaviour:

```
?- myapply([a,b,c,d,e,c], [(a,f), (c,3), (g,7)], R).
R = [f, b, 3, d, e, 3] .
?- myapply([b,a,a,b], [(a,b),(b,a)], R).
R = [a, b, b, a] .
```

A definition of myapply is:

```
myapply([], _, []).
myapply([H|T], Sub, [H1|T1]) :-
    app(H, Sub, H1),
    myapply(T, Sub, T1).
```

(a) [3 marks] What is the first answer to the query

```
myapply([b,a,a,b], S, [c,c|R]).
```

(b) [7 marks] Implement `app` so it works with `myapply`. The only predefined predicate you may use is *dif*(X, Y) that is true when X and Y are different.

Question 5 [3 marks]

Complete the following sentences

(a) I like

(b) I dislike

(c) I wish