Enrolment Number:

The University of Melbourne
School of Computing and Information Systems

Semester 1, 2018 Sample Assessment

COMP90048 Declarative Programming

Reading Time: 15 minutes

Total marks for this paper: 100

Writing Time: 2 hours

This paper has 12 pages.

Authorised Materials:

Writing instruments (e.g., pens, pencils, erasers, rulers).
No other materials and no electronic devices are permitted.

Instructions to Invigilators:

Students will write their answers in the exam paper itself.

The exam paper must remain in the exam room and be returned to the subject coordinator.

Instructions to Students:

Write your enrolment (student) number in the box above. Answer questions directly on this exam paper in the box(es) provided. Use the flip sides of pages for rough work. The last 2 pages are provided in case you need more space for any answers. If you use this overflow space, put a note where the answer belongs saying where the rest of the answer is.

The marks for each question are listed at the beginning of the question. You should attempt all questions. Use the number of marks allocated to a question as a rough indication of the time to spend on it. We have tried to provide ample space for your answers; do not take the amount of space provided for an answer as an indication of how much you need to write.

This paper must *not* be lodged with the university library.

Examiners' use:

1	2	3	4	5	6	**Total**

Question 1 [12 marks]

For each of the following Haskell expressions, give its **type** (which may be a function type, may include type variables, and may include type class constraints) or indicate that it represents a type error. You need not write anything other than the type, or that it is an error.

(a) `(<)`

(b) `map (+3)`

(c) `foldr`

Use this page for scratch work. **Work written here will not be assessed.**

(d) `Nothing`

(e) `zip [True,True,False]`

(f) `flip filter "hello"`

Question 2 [12 marks]

For each of the following Haskell expressions, give its **value**, or explain why it will produce an error or fail to terminate. Assume the `Data.List` library is loaded, which defines the `sort` function.

(a) `map (length < 3) [[1],[1,2,3]]`

(b) `filter (not.(==3)) [1,2,3]`

(c) `let e = head [] in 3`

Use this page for scratch work. **Work written here will not be assessed.**

(d) `map fst $ filter snd $ zip "abcde" [True,True,False,True]`

(e) `head $ sort $ zip [3,0,0,2,0] $ reverse [9,0,0,4,8]`

(f) `map snd $ sort $ zip "decl" [1..]`

Use this page for scratch work. **Work written here will not be assessed.**

Question 3 [30 marks]

Consider the following Haskell type for ternary trees:

```
data Ttree t = Nil | Node3 t (Ttree t) (Ttree t) (Ttree t)
```

Suppose we have a `Ttree` of Doubles and we want a function to find the average of the numbers in the tree. Write a Haskell function which performs this task. If the `Ttree` is empty, your function should return 0.0. Include type declarations for all your functions. To obtain maximum marks, your code should use a single traversal over the tree and have $O(N)$ worst case time complexity.

Use this page for scratch work. **Work written here will not be assessed.**

Question 4 [10 marks]

Give the formal semantics (meaning) of the following Prolog program. Recall that the formal semantics of a logic program is the set of *ground unit clauses* that would give the same answers to all queries as the program itself. English descriptions of the meanings of the programs will receive no credit.

```
p(a).    p(b).

q(X,Y) :- p(X), p(Y).

r(a,c).    r(d,b).

s(X,Y) :- q(X,Y), r(X,_), r(_,Y).
```

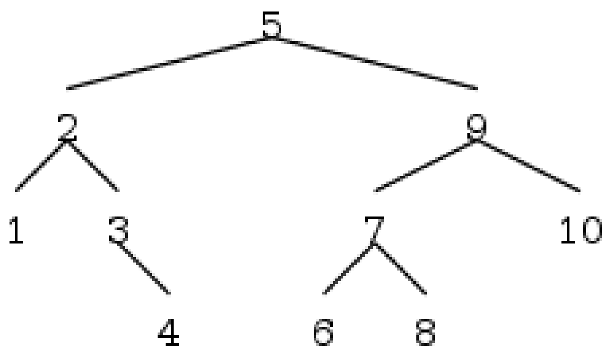
Use this page for scratch work. **Work written here will not be assessed.**

Question 5 [20 marks]

For this question, we will represent a set of integers as a binary tree in Prolog, using the atom `empty` to represent an empty tree or node, and `tree(L,N,R)` to represent a node with label `N` (an integer), and left and right subtrees `L` and `R`. Naturally, we also insist that `N` be strictly larger than any label in `L` and strictly smaller than any in `R`. We do not require that the tree be balanced. For example,

```
tree(tree(tree(empty, 1, empty),
          2,
          tree(empty, 3, tree(empty, 4, empty))),
     5,
     tree(tree(tree(empty,6,empty),
               7,
               tree(empty,8,empty)),
          9,
          tree(empty, 10, empty)))
```

is one possible representation of the set of numbers from 1 to 10. It might be visualized as



Write a predicate `intset_insert(N, Set0, Set)` such that `Set` is the same as `Set0`, except that `N` is a member of `Set`, but may or may not be a member of `Set0`. That is, either `N` is a member of `Set0` and `Set = Set0`, or `N` is not a member of `Set0` and is a member of `Set`, and other than that, `Set` is the same as `Set0`. This predicate must work as long as `N` is bound to an integer and `Set0` is ground.

Hint: Prolog's arithmetic comparison operators are `<`, `>`, `=<` (not `<=`), and `>=`. You can also use `=` and `\=` for equality and disequality.

Please write your answer on page 9.

Answer to Question 5

Use this page for scratch work. **Work written here will not be assessed.**

Question 6 [16 marks]

Following is a definition of a Prolog predicate to compute the sum of a list of numbers.

```
sumlist([], 0).
sumlist([N|Ns], Sum) :-
        sumlist(Ns, Sum0),
        Sum is N + Sum0.
```

Fill in the blanks in the following transformation of this code to be tail recursive.

```
sumlist(List, Sum) :- [                              ]

sumlist([                              ]).
sumlist([N|Ns], Sum0, Sum) :-
        [                              ],
        sumlist([                              ]).
```

Use this page for scratch work. **Work written here will not be assessed.**

Overflow Answer Page 1

You may use this space to continue any answer, but if you do, indicate *clearly* in your previous answer that you have continued onto this page, or this part of your answer may be overlooked.

Overflow Answer Page 2

You may use this space to continue any answer, but if you do, indicate *clearly* in your previous answer that you have continued onto this page, or this part of your answer may be overlooked.

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