0/20 Questions Answered

Final Exam: Multiple-Choice and T/F Questions

STUDENT NAME

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Q1 Acknowledgment

0 Points

Australian National University

NATURAM PRIMUM COGNOSCERE RERUM

COMP1130 Final Exam, Semester 1 2021

You must acknowledge the following **integrity pledge** before proceeding. Please read carefully and check all the boxes.

- [ ] I am committed to being a person of integrity.
- [ ] I pledge, as a member of the ANU community, to abide by and uphold the standards of academic integrity outlined in the ANU statement on honesty and plagiarism, I am aware of the relevant legislation, and understand the consequences of breaching those rules.
- [ ] I will not communicate in any way with anyone else during this exam. This includes asking questions in any online forum.
- [ ] I acknowledge that this exam is protected by copyright and that copying or sharing any of its content will violate that copyright.

Read and check off the following instructions:

1. This examination is timed.

- [ ] Note the remaining time at the top right of this screen. Set an alarm for yourself if you need one.

2. Permitted materials. This is an open book exam. You might in particular find the **course Website**, the **Prelude documentation**, and the **Data.List documentation** useful.

- [ ] You may use any documentation you wish but **all work must be your own**.

Save Answer

Q2 Multi-choice

12 Points

Select one correct answer for each question. Correct answers receive full points. Incorrect answers receive no points.

Q2.1 Code Quality
2 Points

Which of the following are True?

- ○ One can show the absence of bugs through testing.
- ○ You cannot write black box tests for your own code.
- ○ Comments, type declarations, and unit tests should explain how functions work.
- ○ Randomised testing can exhaustively test special cases.
- ○ White box testing enables testing the boundaries where the program makes choices of input.

Save Answer

Q2.2 Parametric polymorphism
2 Points

Which of the following is True in Haskell?

- ○ It is always better to make functions to be polymorphic.
- ○ A polymorphic list can contain elements with different types.
- ○ The type variables should be instantiated to the same type in `id :: a -> a`
- ○ In parametric polymorphism, the function definition needs to be overridden based on the instantiation.
- ○ Any function can be written as a polymorphic function.

Save Answer

Q2.3 Lists and Recursion
2 Points

Which of the following are True in Haskell?

- ○ All algebraic data types can be recursively defined.
- ○ Recursions that compute from the right and the left of lists produce the same results.
- ○ Recursion can be achieved via multiple functions that call each other.
- ○ A pair cannot contain elements of different types.
- ○ `head lst` and `lst!!1` returns the same output.

Save Answer

Q2.4 Higher Order Functions

2 Points

Consider a function `foo` with the following type signature:

```
foo :: Double -> String -> Int
```

Suppose that `foo` can in general run without producing errors. What would happen if you tried to run `foo 0` in ghci?

- ○ You would get an error because `0` is not a `Double`; you should have written `0.0`.
- ○ You would get an error because `foo` requires two inputs, and only one has been provided.
- ○ You would get an error because `foo` takes a function of type `Double -> String` as input.
- ○ You would get an error because function types are not instances of the `Show` typeclass.
- ○ You would not get an error.

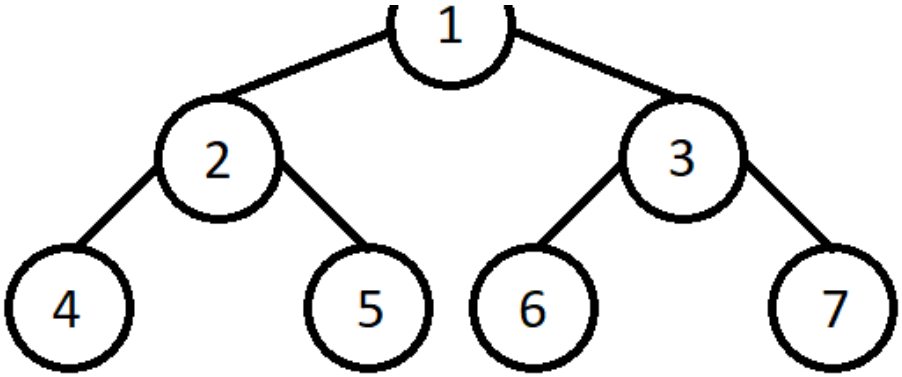
Save Answer

Q2.5 Binary Search Trees

2 Points

Which of the following is a binary search tree?

- ○ 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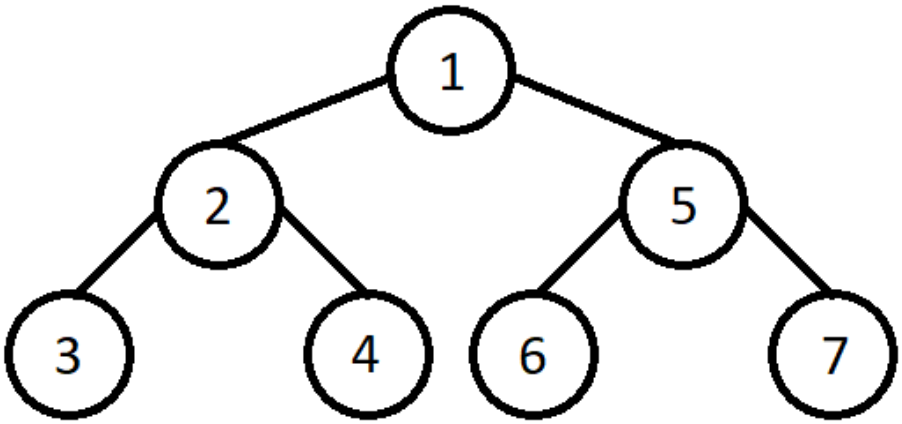
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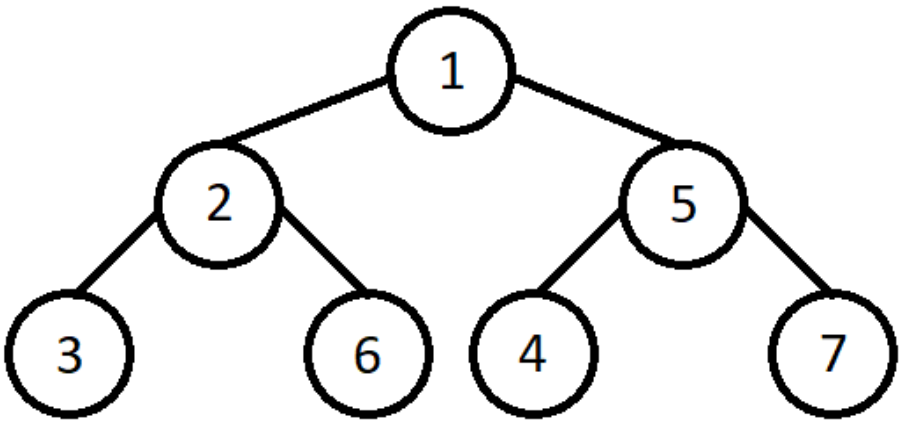
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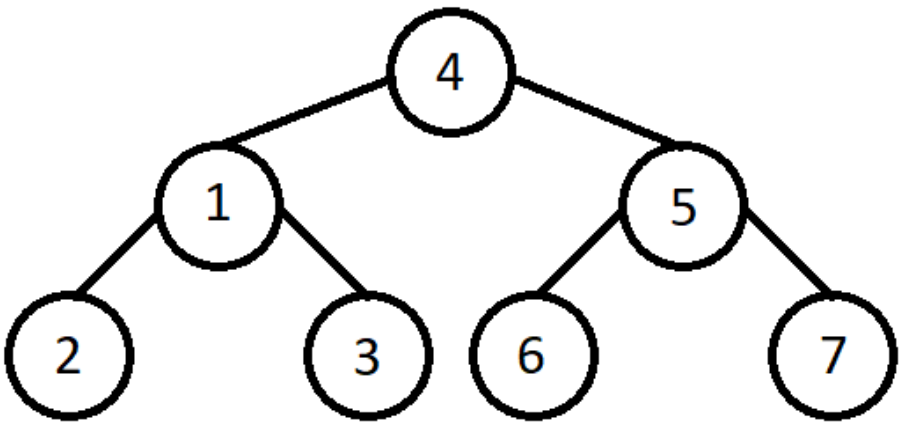
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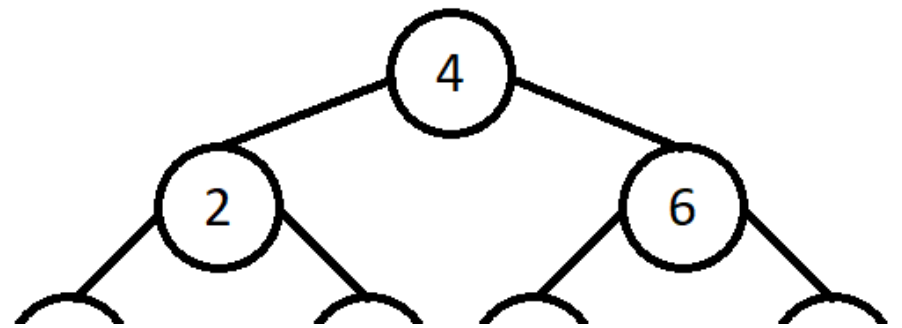
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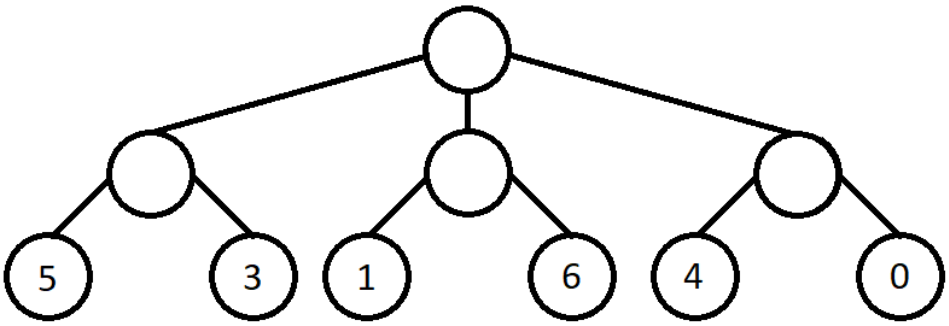
Save Answer

Q2.6 Alpha-Beta Pruning

2 Points

Suppose that you are playing a two player game with alternating turns, and are using the alpha-beta pruning algorithm with lookahead 2, and it is your turn. Suppose the complete game tree looks as follows, with the values your heuristic would calculate indicated on the bottom level:



Which of the leaves of the tree, if any, will your algorithm prune (not visit)?

- ○ The leaves with values 1, 6, 4, and 0.
- ○ The leaves with values 1 and 0.
- ○ The leaf with value 6.
- ○ The leaf with value 0.
- ○ It will not prune any leaves.

Save Answer

Q3 Lambda Calculus

15 Points

In your answers below you may write `\` for λ. Write `->` to indicate that an expression beta-reduces to another, and `<-` if you wish to indicate that an expression beta-reduces *from* another.

For example:

```
   (\x. x) y
-> y
<- (\x. y) z
```

Q3.1 Pairs

2 Points

Using the standard lambda-calculus encoding for pairs:

```
(A,B) = \x. x A B
```

define a lambda-term `P` which has the following property:

```
P F (A,B) = F A B
```

You may find it useful to use other combinators for pairs and Booleans to help design your answer, but give your final answer as a lambda-term only, with no abbreviations. Ensure that your answer is in normal form with respect to non-deterministic evaluation.

Enter your answer here

Save Answer

Q3.2 Reductions

3 Points

Show that your lambda-term `P` from the previous question indeed has the desired property, i.e. `P F (A,B) = F A B`. Present every step of your reductions.

Again, do not use abbreviations; work with lambda-terms only.

Enter your answer here

Save Answer

Q3.3 Fixed Points

2 Points

Consider the following combinator `T`

```
T = (\x. \y. y (x x y))
```

Show using non-deterministic evaluation that

```
T T
```

is a *fixed point* combinator, i.e. that `T T F` is beta-equal to `F (T T F)` for any lambda-term `F`. Present every step of your reductions.

Enter your answer here

Save Answer

Q3.4 Lists

4 Points

Suppose that someone had used the lambda-calculus to encode lists, and in particular had correct encodings for `[]`, `(:)`, `head`, `tail`, and `null` (the function that returns `True` if a list in empty, and `False` otherwise).

Using any of these combinators, and any other combinators that you saw in lectures, write a lambda-term for `foldr`.

Thus, you want your term to have the properties

```
foldr F B [] = B
foldr F B (X : XS) = F X (foldr F B XS)
```

Enter your answer here

Save Answer

Q3.5 Lazy Evaluation

4 Points

Use **lazy** evaluation to reduce

```
(\x. \y. x y) (\z. y) ((\z. z) x)
```

as far as possible. Present every step of your reductions.

Enter your answer here

Save Answer

Q4 Program Proof

10 Points

Consider the following Haskell functions:

```
swap :: (a,b) -> (b,a)
swap (x,y) = (y,x)                          -- (SW)

consLeft :: a -> ([a],b) -> ([a],b)
consLeft x (xs,y) = (x:xs,y)                -- (CL)

split :: [a] -> ([a],[a])
split []     = ([],[])                      -- (S1)
```

```
split (x:xs) = consLeft x (swap (split xs)) -- (S2)

join :: ([a],[a]) -> [a]
join ([],ys)     = ys                        -- (J1)
join ((x:xs),ys) = x : join (ys,xs)          -- (J2)
```

Your task will be to prove the following equality:

```
join (split xs) = xs
```

for any list xs.

In all questions below, make sure that you are clear about which proof techniques you are using, and what the different parts of your proof are. For example, if you are using induction, make sure that you say explicitly that you are doing so, and clearly indicate which part of your proof corresponds to the base case(s) and step case(s), and what your induction hypothesis is. Further, make sure that you write out every line of your argument, and give a reason for each step beside that line. For example, if an equation follows from the first line of the definition of join, write `(J1)` beside it.

Q4.1 Lemma 1

5 Points

Prove the lemma

```
join (consLeft x pair) = x : (join (swap pair))
```

using any techniques that you wish to use.

If you refer to this lemma in any later part of this question, call it `(Lemma1)`. If you can prove the target theorem without this lemma that is fine, but you must still complete this proof to achieve the marks associated with this question.

Enter your answer here

Save Answer

Q4.2 Additional Lemmas
0 Points

This box provides space for any other lemmas you might wish to prove in order to prove your target theorem. Give any lemmas you prove here a name so that you can refer to them later.

Although this question is not explicitly worth marks, your proof of the target theorem must be complete, and adding additional lemmas here might be useful for you to achieve this.

Enter your answer here

Save Answer

Q4.3 Theorem
5 Points

Prove the theorem `join (split xs) = xs`.

Enter your answer here

Save Answer

Q5 Complexity
8 Points

Consider each of the following functions and select its time complexity. Each function has the same best, worst, and average case, time complexity.

Select one correct answer for each question. Correct answers receive full points. Incorrect answers receive no points.

Q5.1
2 Points

What is the time complexity of the Prelude function `map`?

- $O(1)$
- $O(n)$
- $O(n^2)$
- $O(n^3)$
- $O(2^n)$

Save Answer

Q5.2
2 Points

Consider the following function:

```
-- | prefixes
--
-- Returns the list of all possible initial
-- segments of the input list.

prefixes :: [a] -> [[a]]
prefixes list = [] : case list of
  []   -> []
  x:xs -> map (x:) (prefixes xs)
```

What is the time complexity of `prefixes`?

- $O(1)$
- $O(n)$
- $O(n^2)$
- $O(n^3)$
- $O(2^n)$

Save Answer

Q5.3
2 Points

Consider the following function:

```
-- | suffixes
--
-- Returns the list of all possible final segments of the input li

suffixes :: [a] -> [[a]]
suffixes list = list : case list of
  []   -> []
  _:xs -> suffixes xs
```

What is the time complexity of `suffixes`?

- $O(1)$
- $O(n)$
- $O(n^2)$
- $O(n^3)$
- $O(2^n)$

Save Answer

Q5.4

2 Points

Consider the following function:

```
-- | infixes
--
-- Returns the list of all possible contiguous sublists of the inp

infixes :: [a] -> [[a]]
infixes list = case list of
  []   -> [[]]
  x:xs -> map (x:) (prefixes xs) ++ infixes xs
```

What is the time complexity of `infixes`?

- $O(1)$
- $O(n)$
- $O(n^2)$
- $O(n^3)$
- $O(2^n)$

Save Answer

Q6 Programming Questions

55 Points

Code templates for all programming questions in this exam can be found in the zip file here.

We recommend that you use VSCodium for your programming, and that you open the Terminal tool in VSCodium in order to test your code. Non compiling code can result in significant mark deduction or 0. Please make sure each of your Haskell scripts compiles. **Do not change file names.** If you did not attempt or complete some functions, leave them `undefined` instead of commenting out the function definition. Gradescope will give you feedback on whether your code compiles once you upload each Haskell script as well as how many tests it passed. **These tests may not be exhaustive and so passing all the tests may not guarantee full marks.** You can overwrite the previous submission by uploading a new haskell file.

Using the incomplete template scripts, complete the undefined functions (marked with the comment `TODO`). The specification of each function is provided in the comments immediately above the function. You will need to adhere to that specification. You may use the doctests provided to help test your solutions. **These doctests may not be exhaustive**, and so passing all the available doctests may not guarantee full marks. We may also deduct marks for poor style.

Please submit by uploading the Haskell files.

You can find all programming questions on your dashboard as follows:

- Differ.hs [10 points]
- Polymorphic.hs [10 points]
- HOF.hs [10 points]
- Filterable.hs [10 points]
- Trees.hs [15 points]

Save Answer

Save All Answers

Submit & View Submission >