Instructions

Read and follow these instructions carefully to increase your chance of getting good marks.

This is an open book exam. You may use any material that was written prior to the start of the exam, but you must not communicate with anybody else about the exam while it is ongoing (i.e., before 14:00). The use of a Haskell interpreter or compiler is recommended.

Send any questions between 9:00-11:45 on the exam by email to justin.pearson@it.uu.se. It will not be possible to answer questions after 11:45, so please read the whole exam before you start answering questions to see if there is anything that you do not understand. Answers that are relevant for all students will appear in Piazza. If you don't have access, email Justin. We recommend that you check the questions and answers before handing in.

This exam contains several kinds of questions. Among them are multiple-choice questions, where only a single answer is correct (unless otherwise stated). These questions are followed by a motivation question, where you must give a sufficient motivation to why your chosen answer is the correct one. The motivation should relate the information given in the question, the course content, and the chosen answer. The multiple-choice question and its motivation count for one point each.

You can at most obtain 48 points on this exam. The preliminary grade limits are: 24p for grade 3, 34p for grade 4, 44p for grade 5.

Read the questions carefully, and watch out for negations (**not**, **except**, et c.).

Good Luck

1 PKD2-2021-Aug-1.1a

What is the inorder traversal of the expression tree corresponding to ((3 * 1) + (4 - (11 / 5))) + 3?
Välj ett alternativ:

- None of the other alternatives is correct.
- 3 * 1 11 / 5 4 - + + 3
- 3 1 * 4 11 5 / - + 3 +
- 3 * 1 + 4 - 11 / 5 + 3
- + + * 3 1 - 4 / 11 5 3

Totalpoäng: 1

2 PKD2-2021-Aug-1.1b

Motivate your answer to the previous question.

Skriv in ditt svar här

Totalpoäng: 1

3 PKD2-2021-June-1.2a

Consider the following parts of a data-structure invariant for a binary tree where each node has a key of type Int.

1. If the current node is coloured red, then none of its children are coloured red.
2. The key of the current node is less than all keys in the tree rooted at its right child.
3. The key of the current node is less than all keys in the tree rooted at its left child.
4. The key of the current node is greater than all keys in the tree rooted at its left child.

Which combination of these corresponds to an invariant for a binary min-heap?

Välj ett alternativ:

- None of the other alternatives is correct.
- 2 and 4 are true in every node
- 1, 2, and 4 are true in every node
- 2 and 3 are true in every node
- 1, 2, and 3 are true in every node

Totalpoäng: 1

4 PKD2-2021-Aug-1.2b

Motivate your answer to the previous question.
Skriv in ditt svar här

Totalpoäng: 1

5 PKD2-2021-Aug-1.3a

How many nodes are there at least in a red-black tree of height 3?
Välj ett alternativ:

- 127
- 5
- 3
- 4
- 7

Totalpoäng: 1

6 PKD2-2021-Aug-1.3b

Motivate your answer to the previous question.
Skriv in ditt svar här

Totalpoäng: 1

7 PKD2-2021-Aug-1.4a

The worst-case time complexity of insertion into a binary min-heap with n elements is
Välj ett alternativ:

- O(n)
- O(n^2)
- None of the other alternatives is correct.
- O((log n)^2)
- O(log n)

Totalpoäng: 1

8 PKD2-2021-Aug-1.4b

Motivate your answer to the previous question.
Skriv in ditt svar här

Totalpoäng: 1

9 PKD2-2021-Aug-1.5a

Consider the following declaration, and assume that the function foo is pure.
foo :: Read a => [a] -> [a]
Which alternative below is **false**?
Välj ett alternativ:

- The implementation of foo cannot assume that the type a can be represented as a string via the function show.
- foo [] must return the empty list []
- the type a must belong to the typeclass Read
- The implementation of foo can use the overloaded function read.
- All, or at most two, of the other alternatives are correct.

Totalpoäng: 1

10 PKD2-2021-Aug-1.5b

Motivate your answer to the previous question.
Skriv in ditt svar här

Totalpoäng: 1

11 PKD2-2021-Aug-1.6a

Consider the following operations.
init :: Ast a b
f1 :: Ord a => Ast a b -> a -> b -> Ast a b
f2 :: Ord a => Ast a b -> a -> Maybe b
f3 :: Ast a b -> Ast a b -> Ast a b
Which AST are these operations from?
Välj ett alternativ:

- Stack
- Priority queue
- None of the other alternatives is correct.
- Table
- Set

Totalpoäng: 1

12 PKD2-2021-Aug-1.6b

Motivate your answer to the previous question.
Skriv in ditt svar här

Totalpoäng: 1

13 PKD2-2021-Aug-1.7a

Consdier the following fragment of code

```
twoNumbers :: StdGen  -> (Int, Int)
twoNumbers gen =
  let (x, newGen) = random gen
      (y, newGen') = random newGen
  in (gen,newGen)
seed = 134342300
main :: IO ()
main = do
  let (x,y) = twoNumbers (mkStdGen seed)
  if x == y
    then putStrLn("The numbers are the same.")
    else putStrLn("The numbers are different.")
```

When running the code which of the following statements are true?

Välj ett alternativ:

- When main is run sometimes it prints The numbers are the same and sometimes it prints The numbers are different.
- If you change the value of seed then it is possible to get the message The numbers are different.
- When main is run it always prints The numbers are the same.
- When main is run it always prints The numbers are the different.

Totalpoäng: 1

14 PKD2-2021-Aug-1.7b

Motivate your answer to the previous question.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 1

15 PKD2-2021-Aug-1.8a

Which of the following is ***not*** true about file handling in Haskell?
Välj ett alternativ:

- Reading and writing files must be done in an IO Monad
- It is possible to randomly access elements of a file.
- Haskell can only read files given as command line arguments.
- You can use the do notation to access files.

Totalpoäng: 1

16 PKD2-2021-Aug-1.8b

Motivate your answer to the previous question.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 1

17 PKD2-2021-Aug-1.9a

Consider a table with 25 slots that uses chaining to resolve conflicts. What is the *maximal* possible chain length (worst case) of a single slot when the load factor is 3

Välj ett alternativ:

- None of the above the load factor can never be larger than 1
- 75
- 25
- 30

Totalpoäng: 1

18 PKD2-2021-Aug-1.9b

Motivate your answer to the previous question.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 1

19 PKD2-2021-Aug-1.10a

Consider a hash table with 10 slots using the hash function h(k) = k mod 10 with linear probing, and and the following 10 integers

After insert the following 10 items into the hash table 121, 232, 41, 43, 44 ,78, 77, 21

Which item will be in slot 5 (the slots are numbers 0,1,2, . . . , 9).

Välj ett alternativ:

- 44
- 42
- Nothing
- 21

Totalpoäng: 1

20 PKD2-2021-Aug-1.10b

Motivate your answer to the previous question.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 1

21 PKD2-2021-Aug-1.11a

Given a directed graph with nodes A,B,C,D,E,F,G,H and directed edges

```
A | D , F
B | D , E
C | E
D | H
E | G
F | G
G |
H |
```

Which of the following options is *not* a topological sort of the graph
Välj ett alternativ:

- A,F,D,B,E,C,G,H
- A,F,D,B,E,C,G,H
- C,B,A,D,E,F,G,H
- A,B,C,D,E,F,G,H

Totalpoäng: 1

22 PKD2-2021-Aug-1.11b

Motivate your answer to the previous question.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 1

23 PKD2-2021-Aug-1.12a

Given a graph with nodes A,B,C,D,E,F,G,H and (non directed) edges

```
A | D , F
B | D , E
C | E
D | H
E | G
F | G
G |
H |
```

which of the following is a breadth first search (BFS) order.
Välj ett alternativ:

- A,F,G,D,B,B,E,G
- A,F,C,D,G,B,H,E
- A,F,D,G,B,H,E,C
- F,A,D,G,B,E,H,D
- None of the other alternatives is a breadth-first search order.

Totalpoäng: 1

24 PKD2-2021-Aug-1.12b

Motivate your answer to the previous question.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 1

25 PKD2-2021-Aug-2.1

Consider a binary search tree where each node contains a key of type Int.

Write down the datatype, and two recursive functions that yield the smallest and the greatest element in the tree, respectively. Document your code.

Make sure that they have optimal worst-case time complexity, and argue why this is true.

Skriv in ditt svar här

```
1
```

Totalpoäng: 4

26 PKD2-2021-Aug-2.2

Consider a binary search tree with more than one element.

We say that a node is *to the right of* another node if it is in the subtree rooted at that node's right child. A node is to the right of a path in the tree if it is to the right of any node in the path.

Is it always true that all nodes to the right of a path from the root to a leaf have a key that is greater than or equal to that of all nodes on the path?

Motivate your answer.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 4

27 PKD2-2021-Aug-2.3

Recall the ADT queue with the functions enqueue, dequeue, and peek.
Implement a queue where the type Queue a of a queue containing elements of type a is

data Queue a = Empty | Queue a (Queue a)

Document the code.
Skriv in ditt svar här

```
1
```

Totalpoäng: 4

28 PKD2-2021-Aug-2.4

Consider the following function that is supposed to remove duplicate entries in a list of integers.

```
remove_duplicates :: [Int] ->  [Int]
remove_duplicates [] =  []
remove_duplicates [x] = [x]
remove_duplicates (x : xs)   = if x `elem` xs
                             then xs
                             else ( x : remove_duplicates xs)
```

The function is not correct. Your job is to work out why and correct it:

- Write 3 test cases that show when the function is not performing correctly.
- Provide a corrected version of the above function.

Skriv in ditt svar här

```
1
```

Totalpoäng: 4

29 PKD2-2021-Aug-2.5

Ersätt med din uppgiftstext...

The following piece of code is an attempt to do the classic FizzBuzz puzzle. If a number is divisible by 3 then you should `Fizz` if the number is divisible by 5 then you should print `Buzz` and if the number if divisible by both 3 and 5 then print `FizzBuzz`. The two helper functions

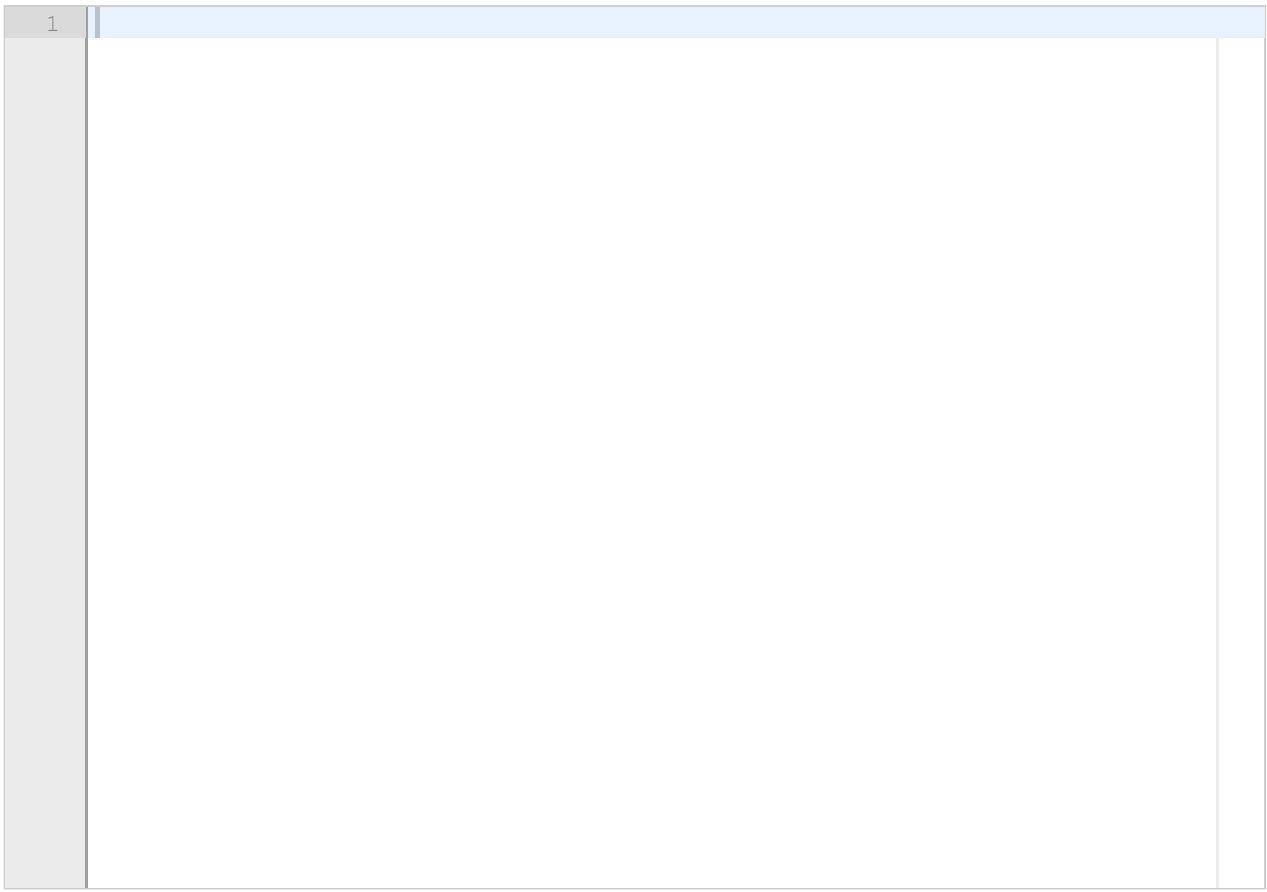
```
fizz  n = if (n `mod` 3) == 0 then "Fizz" else ""
buzz  n = if (n `mod` 5) == 0 then "Buzz" else ""
```

are correct, but the following function program does not work. The idea is you start at `n` and count down until you get to 0.

```
main n =
  if n == 0
  then
    putStrLn "That's all folks."
  else
    str2 <- (buzz n)
    putStrLn ((show n) ++ " is " ++ (fizz n)  ++ str2)
    main (n - 1)
```

1. Explain why the code is incorrect. This does not mean copying and pasting Haskell's error message, but you need to explain what the programmer has misunderstood. Use Haskell comments for your answer.
2. Rewrite the code so that it is correct.

Skriv in ditt svar här



Totalpoäng: 4

30 PKD2-2021-Aug-2.6

Consider the following graph on the nodes A,B,C,D,E,F,G,H,I,J with directed edges

```
A | B
B | E , H
C | D
D | B , C
E | G , F
F | G
H | I , J
I | J , A
J | I
```

1. List all the strongly connected components of the graph.
2. Then apply (Kosaraju) algorithm to compute the strongly connected components. You must explain each step in the algorithm.

Skriv in ditt svar här

Teckenf...

Ord: 0

Totalpoäng: 4