Your exam code: | | | | | | |

Final Exam (Part 2) in Program Design and Data Structures (1DL201)

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Bergsbrunnagatan 15, Hall 1
2014-03-20 / 8:00–13:00

Instructions

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

- This is a closed book exam. You may use a standard English dictionary. Otherwise, **no notes, calculators, mobile phones, or other electronic devices are allowed.** Cheating will not be tolerated.
- Read and follow the instructions on the front sheet.
- In the table below, clearly mark **at most one** answer for each question. (If you think that a question is ambiguous or has no correct answer, mark the question number with a $\star$ and explain on a separate sheet of paper what the problem is and what assumptions you have made to answer the question.)
- Dave Clarke will come to the exam hall around 10:00.

Good luck!

Your Answers

	Question	Answer					Question	Answer				
Grade 3	1	A	B	C	D	E	2	A	B	C	D	E
	3	A	B	C	D	E	4	A	B	C	D	E
	5	A	B	C	D	E	6	A	B	C	D	E
	7	A	B	C	D	E	8	A	B	C	D	E
	9	A	B	C	D	E	10	A	B	C	D	E
Grade 4	11	A	B	C	D	E	12	A	B	C	D	E
	13	A	B	C	D	E	14	A	B	C	D	E
	15	A	B	C	D	E						
Grade 5	16	A	B	C	D	E	17	A	B	C	D	E
	18	A	B	C	D	E	19	A	B	C	D	E
	20	A	B	C	D	E						

Please choose a single answer for each question. Read the questions carefully, and watch out for negations (*not*, *except*, etc.).

Questions for Grade 3

If you answer at least 7 of the 10 questions in this section correctly, your exam grade will be (at least) 3. You cannot compensate incorrect answers in this section with points from questions for higher grades.

1. Consider the following function

```
fun vout (f, b, [])   = b
  | vout (f, b, h::t) = f (h, vout (f, b, t))
```

   What is the value of `vout (op -, 10, [12,3,5])`?

   (A) `~20` (B) `~10` (C) `30` (D) `4` (E) `10`

   Answer: `4`

2. The following program implements part of a binary tree abstract data type and then uses it.

```
 1  abstype stree = Lf | Br of stree * int * stree
 2  with
 3    val empty = Lf
 4    fun insert (i, Lf) = Br (Lf,i,Lf)
 5      | insert (i, tr as Br (t1,j,t2)) =
 6        case Int.compare (i,j) of
 7  EQUAL   => tr
 8          | LESS    => Br (insert(i,t1),j,t2)
 9          | GREATER => Br (t1,j,insert(i,t2))
10
11    fun member (i, Lf) = false
12      | member (i, Br (t1,j,t2)) =
13        case Int.compare (i,j) of
14            EQUAL   => true
15          | LESS    => member (i,t1)
16          | GREATER => member (i,t2)
17
18    fun toList Lf = []
19      | toList (Br (t1,j,t2)) = toList t1 @ [j] @ toList t2
20  end
21
22  val mytree = insert (10, insert (13, insert (11, empty)))
23
24  fun test1 () = toList mytree = [13, 11, 10]
25
26  fun test2 () = member (12, Br (empty, 12, mytree))
```

```
27
28  fun size t = toList t
```

One of the lines in the program is incorrect, in the sense that the program cannot run. Which one? (Note that you do not need to understand how the program actually works.)

(A) `19` (B) `7` (C) `20` (D) `22` (E) `26`

Answer: `26`. (Explanation: The `Br` constructor is used outside the declaration of the abstract data type.)

3. Entries in a stack are "ordered". What is the meaning of this statement?

   (A) There is a first entry, a second entry, and so on.
   (B) Entries are removed in decreasing order.
   (C) A collection of stacks can be sorted.
   (D) The entries must be stored in a list.
   (E) Stack entries may be compared with the $<$ operation.

   Answer: There is a first entry, a second entry, and so on.

4. On an initially empty FIFO queue, carry out the following operations:

   1. enqueue 3
   2. enqueue 4
   3. enqueue 1
   4. dequeue
   5. enqueue 2
   6. dequeue

   What number is now at the head of the queue?

   (A) 4 (B) 2 (C) None. The queue is empty. (D) 3 (E) 1

   Answer: 1

5. Assume that you have been given the task of implementing tables based on lists of key-value pairs. Your programming partner proposes the following as an implementation of the `insert : ('k * 'v) list * 'k * 'v -> ('k * 'v) list` function:

   ```
   fun insert (t, k, v) = (k,v) :: t
   ```

   You are horrified, and give the following reasons why this is a bad idea:

   (a) This code won't type check.
   (b) The function has a larger time complexity than the usual implementation of `insert`.
   (c) Other table functions, such as `delete` and `toList`, will be significantly harder to implement than with the usual implementation of `insert`.

(d) The function will lead to wasted space, because all old elements of the table are stored.

Which reasons are valid?

(A) All of these. (B) a and b (C) b and c (D) c and d (E) b, c and d

Answer: c and d

6. Let H be a hash table of size 1000 using collision resolution by chaining. 650 elements are inserted into H in such a manner that there are 5 chains of length 6, 10 chains of length 5, 20 chains of length 4, 40 chains of length 3, 80 chains of length 2, and the remainder have length 1 or 0. What is the load factor of this hash table?

(A) 440 (B) 0.35 (C) 0.365 (D) 0.65 (E) 210

Answer: 0.65

7. The standard I/O streams are called

(A) standard error, standard warning, standard log
(B) standard blocking, standard non-blocking
(C) standard text, standard binary
(D) standard input, standard output, standard error
(E) standard text, standard audio, standard video

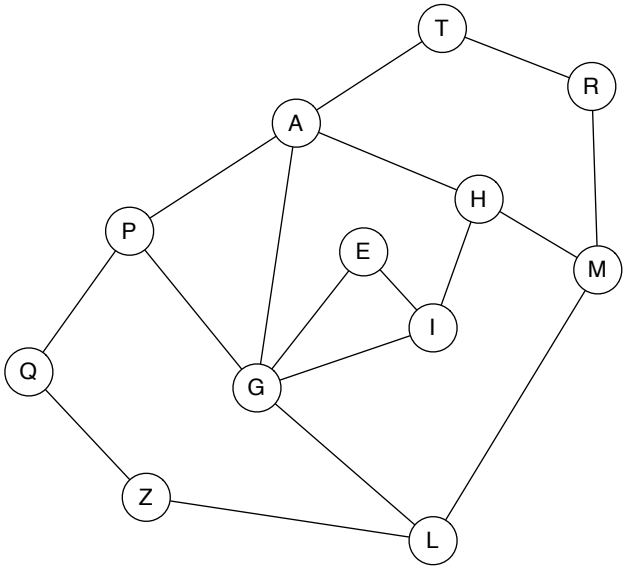
Answer: standard input, standard output, standard error

8. In C programs, execution begins at a function called

(A) `entry` (B) `run` (C) `main` (D) `start` (E) `execute`

Answer: `main`

9. Consider performing a depth-first search on the following graph starting from node Q:



Which of the following sequences corresponds to the visiting order of a depth-first search?

(A) Q P Z G I E A H T R M L
(B) Q Z L M R T A P G E I H
(C) Q Z L G P A R T M H E I
(D) A E G H I L M P Q R T Z
(E) Q P Z G A L T E H I M R

Answer: Q Z L M R T A P G E I H

10. 111 elements are inserted into a binomial heap. What are the sizes of the binomial trees that make up the heap?

(A) 1, 21, 89
(B) 1, 2, 4, 8, 32, 64
(C) 1, 10, 100
(D) 1, 2, 2, 2, 4, 4, 4, 4, 8, 8, 8, 8, 8, 8, 8, 16, 16
(E) It depends on the order in which the elements are inserted.

Answer: 1, 2, 4, 8, 32, 64

Questions for Grade 4

If you answer at least 3 of the 5 questions in this section correctly *and* you pass the criteria for grade 3, your exam grade will be (at least) 4. You cannot compensate incorrect answers in this section with points from questions for grades 3 or 5.

11. What is the most general type of the function `scan` in the following code?

```
fun scanl f q ls = q :: (case ls of
                           []  => []
                         | (x::xs) => scanl f (f q x) xs)

fun scan f (x::xs) =  scanl f x xs
  | scan _ []      =  []
```

(A) `(int -> int -> int) -> int list -> int list`
(B) `('a -> 'b -> 'b) -> 'a list -> 'b list`
(C) `('a * 'a -> 'a) * 'a list -> 'a list`
(D) `('a * 'b -> 'a) * 'a * 'b list -> 'a list`
(E) `('a -> 'a -> 'a) -> 'a list -> 'a list`

Answer: `('a -> 'a -> 'a) -> 'a list -> 'a list`

12. Given an abstract datatype `'a bag`, which represents sets that may include duplicate elements, with the following operations:

```
val putItem    : 'a bag -> 'a -> 'a bag
val getItem    : 'a bag -> 'a option
val isEmpty    : 'a bag -> bool
val isFull     : 'a bag -> bool
val grabAnItem : 'a bag -> 'a
val hasItem    : 'a bag -> 'a -> bool
val totalItems : 'a bag -> int
val emptyBag   : 'a bag -> 'a bag
```

How can a value of this abstract data type be constructed?

(A) It depends upon how the bag is represented.
(B) Using constructors from the underlying data type.
(C) Using `emptyBag` and `putItem`.
(D) Using only `putItem`.
(E) It cannot.

Answer: It cannot. (Explanation: Only `emptyBag` and `putItem` return a bag, but they both require a bag as an argument. Thus, there is no way to construct such a bag argument in the first place.)

13. A stack (as considered in class) has the following signature:

```
val empty   : 'a stack
val isEmpty : 'a stack -> bool
val pop     : 'a stack -> 'a stack
val push    : 'a stack * 'a -> 'a stack
val top     : 'a stack -> 'a
```

What is the value of `top (pop (push (push (push (empty, 10), 12), 11)))`?

(A) `12` (B) A stack containing `11` and `12`. (C) `11`
(D) A stack containing `10` and `12`. (E) The expression does not type check.

Answer: 12

14. Recall the vector data type. Vectors have a fixed size, the time complexity of accessing an element by index is $O(1)$ and the time complexity of inserting an element is $O(n)$, where n is the size of the vector.

Consider the task of implementing a queue using a vector, such that whenever the vector is full, the contents are copied into a new (larger) vector, which then holds the queue. This is called a *resize* operation.

Which of the following statements are true?

(a) Both enqueue and dequeue, ignoring the resize operation, can be implemented in $O(1)$ time.
(b) Either enqueue or dequeue, ignoring the resize operation, must be implemented in $\Theta(n)$ time.
(c) Extending the queue beyond the vector's limit has $O(1)$ time complexity.
(d) Extending the queue beyond the vector's limit has an amortized time complexity of $O(1)$.

(A) b and d (B) a and c (C) b and c (D) a and d (E) None of the above.

Answer: a and d

15. Consider the following SML function.

```
fun f15 x =
  let
    val r = ref x
  in
    while !r mod 2 = 0 do
      r := !r div 2;
    !r
  end
```

What is the value of `f15 12`?

(A) `0` (B) `1` (C) `2` (D) `3` (E) `4`

Answer: 3

Questions for Grade 5

If you answer at least 3 of the 5 questions in this section correctly *and* you pass the criteria for grade 4, your exam grade will be 5. You cannot compensate incorrect answers in this section with points from questions for lower grades.

16. Consider the following hash table of 11 cells, where $\perp$ denotes that a cell was never used and Δ denotes that the element in a cell has been deleted.

0	1	2	3	4	5	6	7	8	9	10
33	23	57	Δ	70	$\perp$	6	$\perp$	19	$\perp$	54

Assume that the hash function is $h(k) = k \bmod 11$, and that open addressing with linear probing function $f(i) = i$ is used as the conflict resolution method.

In which cell will key 109 be placed?

(A) Nowhere. (B) 9 (C) 3 (D) 10 (E) 5

Answer: 3

17. Consider the following SML code.

```
val r = ref 0;
val rr = ref r;
r := 1;
!rr := 2;
rr := ref 3;
```

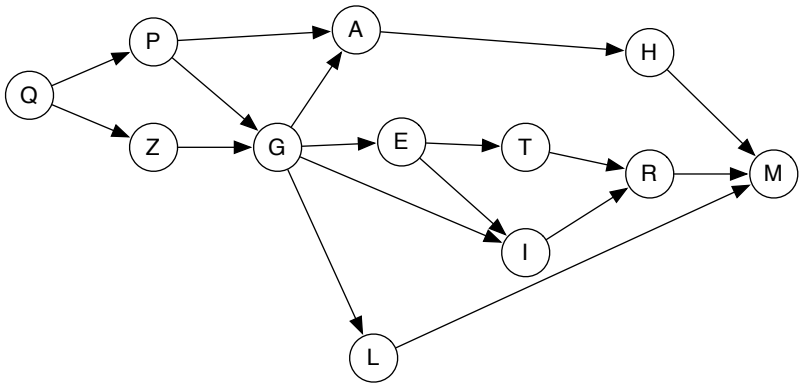
After evaluation of this code, cells containing which values have become garbage (i.e., unreachable)?

(A) `0` and `1` (B) `0`, `1` and `2` (C) `0` and `2` (D) `0`, `1`, `2` and `3` (E) `1` and `2`

Answer: `0` and `1`. (The wording of the question was unfortunate: it confused garbage collection with in-place memory updates. Strictly speaking, there is no garbage here: all three cells created

by calls to `ref` are still reachable. The first cell, initially `0`, now contains a `2`, but is reachable through `r`. The reference to `r` now contains a reference to a cell containing `3`, but is reachable through `rr`. Lastly, the cell containing `3` is reachable through `!rr`. Any explanation along these lines will be accepted as correct.)

18. Consider the following graph:



Assume that midway through performing a topological sort, the last three nodes visited were GAL. What are the candidates for the next node?

(A) E and H (B) E, H, I and M (C) E (D) P and Z (E) None of these.

Answer: E and H

19. Consider the following SML function.

```
fun f19 (name1, name2) =
  let
    val os = TextIO.openOut name2
    val is = TextIO.openIn name1
  in
    while isSome (TextIO.inputLine is) do
      TextIO.output (os, valOf (TextIO.inputLine is));
    TextIO.closeIn is;
    TextIO.closeOut os
  end
```

Assume that the file `x` consists of the following two lines:

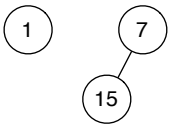
```
Alice
Bob
```

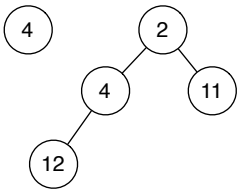
What are the file contents of `x` after evaluation of `f19 ("x", "x")`? (Assume that no I/O error occurs.)

(A)
```
Alice
Alice
```
(B)
```
Alice
Bob
Alice
Bob
```
(C)
```
Bob
Bob
```
(D)
```
Alice
Bob
```
(E) The file is empty.

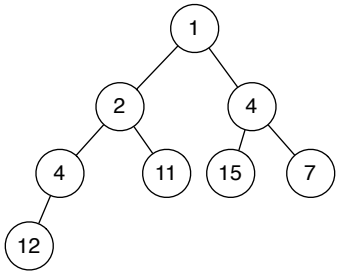
Answer: The file is empty. (Explanation: `TextIO.openOut` truncates `x` to zero length. Subsequent input from `x` returns no data.)

20. What is the result of merging the following two binomial heaps?

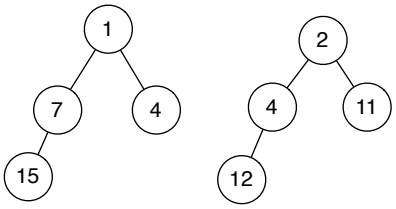




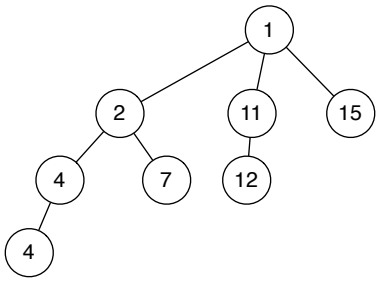
(A)



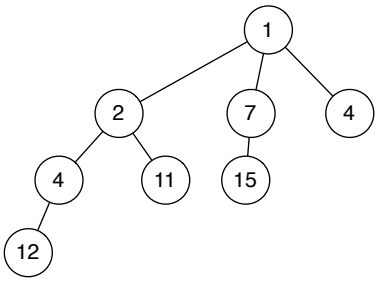
(B)



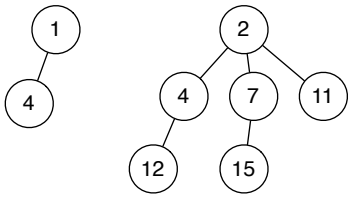
(C)



(D)



(E)



Answer: (D)